Guidelines for Telecommunication DC Systems

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Reference documentation

Report Reference Number	Issuer	Reference	Document name
[1]	SAI Global	AS/ ACIF C524	External Telecommunication Cable Network
[2]	SAI Global	AS/ACIF S008	Requirements for Customer Cabling Products
[3]	SAI Global	AS/ACIF S009	Installation Requirements for Customer Cabling
[4]	SAI Global	AS/NZS 1768	Lightning Protection
[5]	SAI Global	AS/NZS 1939	Degrees of protection provided by enclosure for electrical equipment (IP Code)
[6]	SAI Global	AS/NZS 2676	Guide to Installation, Maintenance, Testing and Replacement of Secondary Batteries in Building
[7]	SAI Global	AS/NZS 3000	Electrical Wiring Rules
[8]	SAI Global	AS/NZS 3008:1.1	Electrical Installations- selection of cables
[9]	SAI Global	AS/NZS 3011.2	Electrical Installations – Secondary Batteries Installed in Buildings, Part 2 – Sealed Cells
[10]	SAI Global	AS/NZS 3012	Electrical Installation – Construction and Demolition Site
[11]	SAI Global	AS/NZS 3015	Electrical installations -Extra Low Voltage (DC) Power Supplies AS/ within Public Telecommunications Networks

Report Reference Number	Issuer	Reference	Document name
[12]	SAI Global	AS/NZS 3084	Telecommunications Installation – Telecommunications pathways and spaces for commercial buildings
[13]	SAI Global	AS/NZS 3100	Approval and test specification – general requirements for electrical equipment
[14]	SAI Global	AS/NZS 3111	Approval and test specification – miniature over current circuit breakers
[15]	SAI Global	AS/NZS 3112	Approval and test specification – plugs and socket outlets
[16]	SAI Global	AS/NZS 3113	Approval and test specification – plugs, socket outlets and couplers for general industrial application
[17]	SAI Global	AS/NZS 3131	Approval and test specification – plugs and socket outlets for stationary appliances
[18]	SAI Global	AS/NZS 3190	Earth Leakage Device Approval and Test Specification
[19]	SAI Global	AS/NZS 3760	In-service Safety Inspection and Testing of Electrical Equipment
[20]	SAI Global	AS/NZ 4044	Battery chargers for stationary batteries
[21]	SAI Global	AS/NZS 4086.1	Secondary Batteries for use with Stand-Alone Power Systems – General
[22]	SAI Global	AS/NZS 4086.2	Secondary Batteries for use with Stand-Alone Power Systems - Installation and Maintenance

Report Reference Number	Issuer	Reference	Document name
[23]	SAI Global	AS/NZS 4836	Safe Working on Low Voltage Electrical Installations
[24]	SAI Global	AS/NZS 5033	Installation of Photovoltaic (PV) Arrays
[25]	SAI Global	AS/NZS 947.3	Low-voltage switchgear and control gear - switches, disconnectors, switch-disconnectors and fuse-combination units
[26]	SAI Global	AS4509.1	Stand-alone power systems – Safety and installation
[27]	SAI Global	AS4509.2	Stand-alone power systems – System design
[28]	SAI Global	AS/NZS 6026	Low voltage fuses
[29]	International Electrotechnical Commission	IEC 61215	Crystalline silicium terrestrial photovoltaic (PV) Modules - Design qualification and type approval
[30]	International Electrotechnical Commission	IEC 61646	Thin-film terrestrial photovoltaic (PV) Modules - Design qualification and type approval
[31]	International Electrotechnical Commission	IEC/EN 61730-1	Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
[32]	International Electrotechnical Commission	IEC/EN 61730-2	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
[33]	NSW Rural Fire Service	NSW Rural Fire Service	Guidelines for Asset Protection Zones

Report Reference Number	Issuer	Reference	Document name
[34]	NSW Rural Fire Service	NSW Rural Fire Service	Practice Note 1/11 - Telecommunications Towers in Bushfire Prone Areas
[35]	NSW Telco Authority	NSWTA Guideline 5	Structural Assessment Guideline for Towers, Masts and Antenna Mounts

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1 Executive Summary

This document defines performance specifications for the selection of DC power systems for communication infrastructure for NSW Government (NSWG). This document will ensure that the design and supply of DC power systems on NSWG sites will be of a standard that will comply with all relevant Australian Standards and reflect the requirements of the services they support.

This performance standard includes specifications for three distinct categories of sites. These will include Small DC Load Sites (DC load less than 1,000W), Medium DC Load Sites (DC load from 1,000 to 5,000W) and Large DC Load Sites (5,000 to 10,000W). In addition, the site requirements will be further specified for each of the four NSW Telco Authority site importance classifications referenced in Section 2.4.

An additional classification for site access will be included where access is restricted e.g. Helicopter or 4WD dry access, flood/ fire prone or commercial restrictions. For each of these cases, specifications will be provided for all relevant DC systems including solar power, backup batteries, conversion systems, and distribution.

2 Introduction

2.1 Purpose

The purpose of this specification is to provide the designer, supplier and the civil contractor (collectively referred to as the Service Provider) with a detailed technical guideline which should be complied with in performing works for the NSW Government.

This specification is applicable for new installations and upgrades to existing site infrastructure. It defines the requirements throughout the asset lifecycle phases including planning, design, construction, operations, maintenance, and disposal.

Variance from this guideline is considered acceptable where the alternative solution meets the objectives of the supported services and facilities in a more cost effective manner, taking total cost of ownership into account.

2.2 Scope

The requirements specified in this document may be applied to all new DC power systems designed and constructed for the NSW Government.

This document must be used in conjunction with normal practice in the telecommunications industry.

In the event that a conflict arises between the requirements of this document and relevant Australian Standard, the mandatory obligations of the Australian Standards shall prevail as follows:

- Commonwealth and State Acts
- Australian Standards, Codes and Regulations and BCA
- NSW Government standards
- Industry standards

It shall be the Service Providers' responsibility to use appropriate standards and codes, and to follow normally accepted practice in the industry where any areas are not covered by this document.

2.3 Safety in design

Safety in design is the recognition that a design decision can lead to hazards being built into a product, building, or structure that may manifest itself during construction, operation, maintenance, disposal or demolition.

The safety in design process represents the conceptualisation of ideas and implementation of strategies, by a professional design team that minimise hazards.

The design team and Service Provider are bound by WHS legislation to record and demonstrate that hazards are eliminated or risk-mitigated for all designs. It should be noted that the Commonwealth WHS Regulations 2011, Chapter 6, Regulation 291 identifies construction work in this field is a high risk activity.

Safety in design endeavours to identify, replace, substitute, or mitigate future WHS risks and hence provide a safer workplace environment for those personnel who will construct, manage, operate, work in, maintain, and ultimately demolish the product, structure, or building.

Australian standards AS3000, AS3015 and AS1768 are to be in all cases paramount. The requirements of the reference documents shall be the minimum acceptable to the Customer.

3 General Principles

The Customer should provide the following information for the site load:

- operational DC Voltage
- peak site load (Watts)
- average site load (Watts)
- future planned load
- site type or classification considering service supported
- site access constraints
- monitoring interfaces and communications protocols to integrate into monitoring systems

All DC system and components will be:

- fully compliant with Australian Standards and all other relevant approvals
- fully supported by the manufacturer/importer/agent for an operational life in the field of 10 years unless specified otherwise by the Customer
- fully documented in accordance with Section 7 of this specification
- designed to meet initial specification over full operational life

When selecting equipment the following should be considered:

- suitability for use in site environment
- ease of transport to and from site
- ease of installation
- ease of operation
- ease of maintenance
- environmentally sustainable construction (e.g. does not contain PCBs, potential for recycling, etc.)
- ease of integration with any existing systems.

4 Telecommunications Site Energy Sources

Within this guideline telecommunication sites are categorised based on the proposed primary energy source to be used. The three categories are, Mains Power, Solar Power and Hybrid Systems. The selection of primary power source will be dependent on the proximity of mains power, space available for installation of solar arrays and the location of site with respect to support staff.

4.1 Mains Power Systems

A DC System nominated as a ‘mains supply system' where the primary power generation source is (consumer) AC mains supply. In this case mains supply power is directly is converted to DC electricity for use by other equipment.

The mains supply system is differentiated from an AC supply in this document in that the mains supply is derived from a connection to an external utility. An AC supply may be provided by a private diesel generator or DC/ AC converter and these are considered separately within this document.

Mains supply distribution within a telecommunications site is to be designed in accordance with the appropriate Australian Standards.

A telecommunications site with mains power may also have a generator as backup.

A DC system at a mains powered site will have AC rectifiers (AC to DC conversion) and a DC distribution system with isolation devices. Furthermore, a DC system at a mains powered site may have batteries for storage and a battery charge controller. Where a generator is provided a power system controller may also be installed.

Large DC systems may include redundancy through dual systems (A and B supplies), multiple battery strings), and redundant AC rectifier modules. These systems would normally be found at Type 1 sites to ensure site resiliency.

DC system design will also require autonomy time to be provided for loss of supply.

All critical equipment required for the operation of a site should be powered from the DC system. AC powered equipment will be powered via a DC/AC inverter connected to the DC supply. This is to ensure that the site will be operational if mains power is lost.

4.2 Solar Power Systems

Solar power systems are suitable where the provision of an AC mains supply connection to a power utility is not practicable, and where the load characteristics are aligned with feasible solar power system solutions. Solar powered sites may also be equipped with a Generator for the mitigation of risk of PV generation failure.

The DC load of the site, time-to-recharge and the battery autonomy time (load supported by battery operation alone) will determine the size of the array, battery storage capacity and ancillary equipment dimensioning. The size of the array required may prohibit installation on sites with limited land area and needs to be considered along with future load requirements.

For DC Load Sites deemed to be type 1 or type 2, solar should be backed up with a secondary source of power as specified by the Customer. The primary option is a diesel generator of suitable capacity to accommodate the site load as well as to recharge the batteries. See section 6.5 for generator specifications. Wind energy as a secondary power source may be considered in exceptional circumstances.

4.2.1 Solar system design

Solar power systems design principles are described below.

Design inputs are to be derived from a solar study and report which must be prepared when proposing a solar design. The solar study and report is to be carried out by a consultant who can demonstrate sufficient experience to the Customer in this area.

The solar study and report must detail as a minimum, load profiles, shade profiles, inclination angles, system architecture, design life calculations, battery capacity and life calculation.

All equipment forming part of a solar power system is to be modular in construction and should meet the relevant sections of this specification.

Type 1 and 2 solar powered sites must also be provided with a generator inlet socket adequately sized for the AC and DC site load for the connection of a portable generator. Provision for onsite battery charging should be made at Type 1 and 2 sites. Permanent or standby generators may be proposed by a Service Provider or the Customer.

Solar power arrays and other components are valuable items and as such theft alarms and security fittings should be provided as specified by the Customer.

4.3 Hybrid Power Systems

Hybrid power systems use a combination of solar and at least one other energy source to provide sufficient power to supply the load and recharge the batteries. The components form an integrated system with system controller to provide a continuous DC supply while ensuring battery charge is within required limits.

The standard configuration utilises a diesel generator as the complimentary power source although wind generators may be considered where circumstances dictate. The generator in a hybrid system contributes to the supply of standard load.

System design is largely affected by the solar array which is dependent on the site size and layout and potential shade from the local environment. The generator runtime and associated fuel storage will then be calculated based on the solar charge capacity and the site load.

The standards for the solar array, solar array structure, diesel generator and solar batteries are listed in separate sections of this document.

4.3.1 Hybrid Power System Design

Design inputs are to be derived from a solar study and report which must be prepared when proposing a hybrid power system design. The solar study and report is to be carried out by a consultant who can demonstrate sufficient experience to the Customer in this area. The result from the solar design will determine the required capacity of the complimentary power source.

The solar study and report must detail as a minimum, load profiles, shade profiles, inclination angles, system architecture, design life calculations, battery capacity and life calculation.

All equipment forming part of a hybrid power system is to be modular in construction and should meet the relevant sections of this specification.

Hybrid power systems incorporating diesel generators must be programmable:

- to allow the generator to be operated at suitable intervals and times to charge the starting battery and top up the site load batteries
- to ensure the generator only charges when the efficiency is greatest e.g. the batteries have reached a sufficient level of discharge to ensure the generator is under load
- to preserve site fuel usage while ensuring the generator is available.

Solar power arrays, diesel fuel and batteries, and other components are valuable items and as such theft alarms and security fittings should be provided as specified by the Customer.

5 Site Power System Components

This section lists the components utilised within a Telecommunications Site Power System.

5.1 DC System Type

This subsection describes the different types, specifications, and configurations of DC systems used within NSW Government sites.

5.1.1 DC Voltages

The following DC voltages and ranges are used within NSW Government Communications Sites.

0V reference

All systems regardless of voltage should be referenced to 0V unless there are valid technical reasons. If not, the Customer must be made aware why this is the case at the proposal stage.

The 0V bonding point must be clearly marked with a dedicated label at each end of the bonding cable. The bonding point must be demarcated and must be at an easily accessed location at each end of the cable. All power systems on a site should be bonded at a common point on site such as the single point connection earth bar.

+12VDC

Nominal voltage, working range must be 10.2-14.4 VDC.

This voltage should be considered for Small DC Load Sites as defined above and where cable lengths will also be short and hence cost to install versus current capacity and volt drop are considered.

-48VDC

Nominal voltage, working range must be -42 to -55 VDC.

This voltage is preferred and should be considered for all Medium or Large DC Load Sites and also Small DC Load Sites if the cable lengths would cause excessive volt drop at 12V operation. Voltage stability of power conversion equipment must be +/-5% under all operating conditions measured at the DC primary distribution busbar.

5.2 AC/ DC Conversion Systems

AC to DC converters (rectifiers) are used to convert AC power from mains power or AC generator power to DC. An AC to DC conversion system at a mains powered site will provide DC power to charge the batteries and supply the equipment load. A rectifier or bank of rectifiers will be capable of providing full load supply to the site equipment without batteries. Rectifiers will have sufficient capacity to support the site DC load and battery charging requirements concurrently.

Rectifiers should be configured with redundancy in line with the importance of the services supported. Tables within Section 9 provide recommendations for redundancy. Rectifier module sizes and numbers should be such that the failure of a single rectifier module will not reduce the capacity of the overall DC system to below the defined load. Rectifier modules should be hot swappable. Expansion of the rectifier capacity should be possible by the addition of extra rectifier modules.

Rectifiers should be controlled and monitored through a DC Power Management System consisting of a local management module which is remotely accessible and controllable over the management network. Where implemented, the DC Power Management System shall provide for control and monitoring of the following parameters: output voltage, load current, temperature compensation, charge equalisation, remote access, low voltage disconnection, event logging and battery diagnostics. The DC Power Management System must also provide a battery discharge test, where batteries are fitted, that can be initiated automatically or remotely. The battery discharge test should provide an estimate of the battery capacity.

Rectifier systems and installation must comply with all applicable Australian Standards and the redundancy provisions listed in the site type tables in Section 9.

The rectifiers and Power Management System should have local and remote operation in accordance with the Customer interfacing specification.

5.3 DC / DC Conversion Systems

DC to DC conversion systems provide efficient conversion from one DC voltage to another. Typically, in a telecommunications environment, these will be -48VDC to +12VDC or +12VDC to -48VDC. Where redundancy is required, appropriate managed systems with redundant converter modules should be utilised.

DC to DC systems must be designed and installed to meet the load requirements of the site. DC to DC systems and installation shall comply with all applicable Australian Standards.

The DC to DC Converter System should have local and remote operation in accordance with the Customer interfacing specification.

5.4 DC / AC Conversion Systems

DC to AC Conversion Systems (inverters) are used to provide a reliable and low sine wave distortion single phase 240AC supply at DC powered sites or from a critical DC supply. Where inverters are used to supply critical systems, redundancy provisions should be made.

DC to AC systems must be designed and installed to meet the AC load requirements of the site. DC to AC systems and installation shall comply with all applicable Australian Standards.

The DC to AC Converter System should have local and remote operation in accordance with the Customer interfacing specification.

5.5 Generators

Diesel fuel generators should be the standard generator for NSW communication sites. Liquefied Petroleum Gas (LPG) generators should only be considered in exceptional circumstances. In all cases selection of a generator shall include a risk assessment considering environmental impacts, transportation of fuel and spares, decanting and storage, theft, vandalism and fire dangers.

Fuel storage should be fully detailed in the Customer’s preliminary design. Fuel storage shall be bunded and all appropriate isolation methods incorporated. Consideration must be given to refuelling operations and fire suppression provided.

Fuel storage should be provided for Type 1 and 2 sites ideally for 6 months and as a minimum for the period which access may be prohibited (e.g. snow season). Typical run times under diesel generation should not exceed 20% of the required power generation with a design objective of less than 10% of the required power supply.

The diesel generator must be housed in an environmental enclosure that will meet the site specific conditions regarding acoustic performance, emissions output and other considerations that will be specified by the Customer.

Integral fire suppression systems must be included as part of the generator. The fire suppression system is to be automatically initiated, sufficient to extinguish any likely fire duration, suitable for use around an electrical system, environmentally acceptable/ compatible with no risk to organic life and leave minimal clean-up operations.

The diesel generator should be provided with a control system suitable for the environment in which the generator is to be placed, have local and remote operation in accordance with the Customer interfacing specification and have alarms in accordance with Section 0 of this guideline document.

The diesel generator must be selected with regard to the location and operating conditions (ambient temperature, altitude, climatic etc.) under which it will operate.

Diesel generators must be selected to meet the requirements of Australian Standards as applicable. Care should be taken to not over size the generator to ensure sufficient base loading for stable operation and efficiency. Examples of requirements are:

- Mains Sites - site peak AC load including battery recharge at design rate with additional allowance for surge and an oversize factor.
- Solar and Hybrid Sites – site peak AC and DC load including battery recharge at design charge rate with additional allowance for surge and an oversize factor.

5.6 Photovoltaic Modules

All PV Modules installed must be certified and approved to AS/NZ 5033 photovoltaic installations, and modules must be compliant with IEC 61730 and IEC 61215 and must meet Application Class A of IEC 61730.

Photovoltaic Arrays should be designed to not exceed 120VDC (AS/NZS3000 ELV) (open circuit) in standard test conditions (STC). This is a safety requirement and to eliminate the requirement for only qualified electricians being able to install/alter or maintain the DC power system.

System design of stand-alone power systems that include Photovoltaic Modules are to be designed and installed to AS/NZ 4509 parts 1 and 2.

The solar study provided by the solar consultant as per section 5.2.1 must propose specific PV Modules within an array configuration to meet the above conditions.

5.7 Solar Charge Controller

The preferred solar charge controller type is maximum power point tracker (MPPT) except where noise, system compatibility, relative complexity or cost mitigate against MPPT. The alternate controller type is pulse width modulated (PWM).

The choice of control system is to be made with regard to the size of the DC power system, environmental location of the communications site and customer specifications.

The system should be designed with scalability in mind such that the system can be easily expanded without major modifications. The customer is to specify the anticipated initial and ultimate full system load.

All equipment forming part of a solar power system is to be modular in construction and should meet the relevant sections of this specification.

5.8 Battery systems

All battery systems must conform to the following reference documents, AS/NZS 2676, AS/NZS 3000, AS/NZS 3015, AS/NZS 3011, AS/NZS 3100, AS/NZS 3111, AS/NZS 40862.2, AS/NZS 5033, and AS/NZS 60269.

All batteries should be:

- fully compliant with Australian Standards and all other relevant approvals
- dimensioned, designed and fully supported by the manufacturer/ importer/ agent for an operational life of greater than or equal to 7 years before replacement in the installed environment unless specified otherwise by the Customer
- installed in dedicated battery storage racking
- manual handling must be a consideration. Racks shall be accessible and such that the use of mechanical aids shall be avoided where at all possible for battery installation into the rack.
  - low self-discharge
  - maintenance free
  - operable over a temperature range of -20°C to +60°C
  - cell format enabling them to be connected for operation as 12V or 48V strings. For Sites with > 5 kW cells may be sized to suit the system proposed
    - String numbers are to be sized for the full DC load of the installation.
    - Type 1 sites are to have two strings as a minimum requirement regardless of DC maximum demand. Each string shall be individually protected by a fuse, circuit breaker or other suitable protection device at the closest point practicable to the battery terminals.

Additionally;

- batteries should be front terminal-type in order to allow ease of installation and maintenance
- each battery string connection at the DC power system is to have its discrete disconnect fuse/ Miniature Circuit Breaker (MCB) connecting the string to the charging DC supply
- for Type 1 sites a remote operation battery low voltage disconnect override should be provided. For Type 2 sites a remote operation battery low voltage disconnect override may be provided.
- the battery charging systems shall be sized suitably so as to provide a continuous and sufficient DC power source to the control and operating equipment
- the charging system must also be capable of supplying the required load while recharging batteries to full capacity without using any rectifier capacity installed for redundancy purposes
- at solar sites the batteries should be designed/ sized/ specified for a maximum 20% daily cyclic discharge under normal operation and 80% depth of discharge in extreme conditions. Extreme conditions should be defined by the Customer in the site specific scope of works
- at hybrid sites the generator should begin operation at no greater than 60% depth of battery discharge and cease operation at 10% of battery depth of discharge

- design is to incorporate de-rating factor for aging of all components so that the capacity required is maintained for a period of seven years

All battery systems must be provided with adequate ventilation in accordance with requirements outlined in AS/NZS 3011 – electrical installations – secondary batteries installed in buildings and AS/NZS 3015 – electrical installations – extra low voltage (DC) power supplies within public telecommunications networks.

5.8.1 Batteries (non-solar)

Battery systems should be provided with a capacity based on complete calculated DC load and sustained operating times. Sustained operating times after the loss of the primary energy source are established based upon the site type, accessibility and the timeframe to reach site from service location (mobilisation).

Battery backup time = mobilisation period + rectification allowance + contingency.

Contingency is varied according to the importance of the site continuing to operate.

Recommended minimum autonomy periods for support of DC load are shown in Table 1. Refer to Table 9 for detailed review autonomy recommendations. The recommendations give consideration to events where multiple sites lose AC mains power (e.g. cyclone or AC grid failure).

Site Type	Site Use	Minimum recommended Autonomy Times
Type 1 site	Mission Critical	Unrestricted Access: 10 hours (2 hours for mobilisation, 4 hours for rectification, 4 hours margin) Semi-restricted Access: 16 hours (8 hours for mobilisation, 4 hours rectification, 4 hours margin) Restricted Access: 36 hours
Type 2 site	Operational	Unrestricted Access: 8 hours (2 hours for mobilisation, 4 hours for rectification, 2 hours margin) Semi-restricted Access: 12 hours (8 hours for mobilisation, 2 hours rectification, 2 hours margin) Restricted Access: 36 hours
Type 3 site	Business	Unrestricted Access: 3 hours (2 hours for mobilisation,1 hour for rectification, 0 hour margin) Semi-restricted Access: 8 hours (6 hours for mobilisation, 2 hours rectification, 0 hours margin) Restricted Access: 24 hours

Site Type	Site Use	Minimum recommended Autonomy Times
Type 4 site	Information	Unrestricted Access: 0 hours) Semi-restricted Access: Customer to determine Restricted Access: Customer to determine

Table 1 - DC Load Capacity (non-solar)

Unrestricted access mobilisation times have been nominated on the basis that 80% of all sites in the jurisdiction of the Customer will be within 4 hours driving time from a service location.

Semi-restricted access requirements are based on loss of power during storms, flooded or cut roads, fires, or any other condition that renders access semi-restricted. Restricted access is where alternate forms of transport or arrangements with long lead-times are required restricting the ability to easily visit the site at all times. The autonomy time allows for access via non-conventional means to be determined during the event e.g. Helicopter. The Customer may vary these times on a site by site basis. Restoration or recharge times should be as tabulated in Table 2.

Site Type	Site Use	Recharge Rates
Type 1 site	Mission Critical	Recharge time 10 hours (C10 rate)
Type 2 site	Operational	Recharge time 20 hours (C20 rate)
Type 3 site	Business	Recharge time 20 hours (C20 rate)
Type 4 site	Information	Recharge time 20 hours (C20 rate)

Table 2 - Recharge times (non - solar)

5.8.2 Batteries – (Solar)

Battery systems supplied as part of a solar system should be provided with a capacity based on complete calculated DC load and autonomy time. Solar sites that do not have a backup generator are designed have sufficient capacity to maintain operation during periods of low charge. Low charge may be caused by low light conditions from overcast weather, smoke or dust, vandalism, or failure of the solar array.

Solar sites tend to be in remote areas where mains power is not available. Sufficient solar capacity (array and storage) is required to maintain operation 24/7 including times of low input charge. The array must have sufficient capacity to recharge the batteries and service the load within the charging window. The DC load capacity should be sustained for the time periods shown in Table 3.

Autonomy is based on AS 4509-2 example of typical autonomy times for various applications where a generator if available will be auto-start, and the probability of the number of consecutive days of low solar irradiation is 4 to 5.

Recommended minimum autonomy periods for support of DC load are shown in Table 3. Refer to Table 10 and Table 11 for detailed review autonomy recommendations.

Site Type	Site Use	Recommended Minimum Autonomy Times
Type 1 site	Mission Critical	Unrestricted Access – no generator: 120 hours Semi-restricted Access – no generator: 144 hours Restricted Access: - no generator 168 hours Generator backup: 72 hours
Type 2 site	Operational	Unrestricted Access – no generator: 120 hours Semi-restricted Access – no generator: 120 hours Restricted Access: - no generator 144 hours Generator backup: 72 hours
Type 3 site	Business	Unrestricted Access – 96 hours Semi-restricted Access – 120 hours Restricted Access: - 144 hours Generator backup: 72 hours
Type 4 site	Information	Unrestricted Access: 96 hours Restricted Access: 96 hours Restricted Access: - 120 hours Generator backup: 72 hours

Table 3 - DC Load Capacity (Solar)

These values may be varied by the Customer due to local conditions. Restoration or recharge times for solar sites should be as tabulated in Table 4.

Site Type	Site Use	Recharge Rates

Type 1 site	Mission Critical	Recharge time 10 hours (C10 rate) (2 full days of sunshine)
Type 2 site	Operational	Recharge time 15 hours (C20 rate) (3 full days of sunshine)
Type 3 site	Business	Recharge time 20 hours (C20 rate) (4 full days of sunshine)
Type 4 site	Information	Recharge time 20 hours (C20 rate) (4 full days of sunshine)

Table 4 - Recharge times (Solar)

As the discharge of batteries is normal in a Hybrid System, response and restoration will not commence until majority of battery capacity has been expended.

The table above assumes 5 hours peak sun hours with the PV array output sufficient to supply load and recharge the batteries at the nominated rate. These values may be varied by the Customer due to local conditions e.g. easy access to recharge batteries with a portable generator.

5.9 Battery Chargers

Batteries may be charged through various systems depending on the site power source. Solar sites will charge batteries through the PV Array and Solar Charge Controller. Hybrid sites will include additional battery charging through power supplied by a generator. Mains powered sites will charge batteries based on the type and size of the DC system installed. An integrated DC system including rectifiers and system controller will charge batteries connected to the DC bus. Smaller systems may use a dedicated battery charger to charge batteries used to provide DC power. This section describes the latter dedicated battery charger systems.

AS/NZ 4044 specifies requirements for stabilised constant potential battery chargers that are designed to supply DC power from an AC source while charging a float-type stationary battery which may simultaneously supply power to a connected DC load.

Battery chargers must conform to AS/NZ 4044 and AS 3100.

Battery chargers shall comply with the Type 2 requirements of AS 4044 – Battery chargers for stationary batteries, (i.e. the charger is to be suitable for providing supply to a load with or without a battery connected in parallel) and are to be suitable for rack, wall and floor mounting.

Battery chargers are to be single-phase connected to facilitate connection of a portable generator sets in situations of loss of ac supply. A dedicated socket for connection of a portable generator is to be provided where these systems are installed.

The status of the battery charger should be connected into the alarm system. Status may be from alarm outputs on the charger or battery voltage alarms or both. For details and methodology refer to Customer interfacing specification.

5.10 Distribution and cabling systems

Cable selection must be determined in accordance with the calculated maximum demand of each individual circuit. The maximum demand shall take into account all likely factors affecting the circuit.

The following reference documents also provide guidance on cable selection, AS/NZS 3000, AS/NZS 3008:1.1, and AS/NZS 3015.

In addition, the cable selection process must consider low fire and smoke hazard insulation properties.

All DC power system cabling is to be installed using methods such as cable ducting/ trunking, conduits and trays.

DC power system distribution is to be via a primary distribution system that should be installed in the DC power system rack.

The primary distribution system should consist of all the DC conductors and other equipment from the converter output terminals, up to and including the terminals of a battery and the input terminals of the first switchboard.

The secondary distribution system should consist of the first DC distribution switchboard and the protected circuits originating from it for the purposes of distributing the DC power to the telecommunications equipment.

All DC distribution switchboards in the secondary distribution system should consist of protective devices in a dedicated distribution board (this may from part of an integrated DC power system or be a separate unit). The number of DC protective devices must be sufficient to provide circuits for the anticipated initial and ultimate full system loads.

Where the system complexity requires it, additional secondary DC distribution boards should be provided at equipment rack or similar level. At multi agency sites each co-located agency may have its own dedicated secondary distribution system.

At Type 1 sites, or sites with greater than 5kW of DC Load it is mandatory to provide a clear demarcation point between the primary and secondary distribution systems.

All DC power system distribution is to be installed using dedicated distribution boards and protective devices.

All DC power system cabling insulation is to be coloured red for the positive conductor and blue for the negative conductor. DC power system cabling before circuit breakers must be double insulated and all other cabling should be double insulated and in all cases be multi-stranded. DC power system cabling insulation must be of low smoke and fire hazard type.

DC power system cabling and protective devices must be selected with regard to full load current, charging current, prospective fault current and volt drop.

Battery cabling must provide mechanisms to limit current flow in the protective earth system during fault or short circuit condition.

All other earth cabling minimum size must be 6mm² cross sectional area as per Clause 3.8 of AS 3015.

DC power system cabling conductor material is to be copper.

Separation of DC power cabling must be maintained as required by AS/NZS 3000, AS/NZS 3015, and AS/CIF S009.

5.11 Power system monitoring/alarms

Power system monitoring is desirable in all sites and is essential in for support of type 1 and type 2 service.

Alarms should be indicated locally and remotely. Alarm signals should be communicated remotely using methods as detailed in the Customer's interfacing specification.

All DC power system equipment (AC/DC conversion systems, DC/DC conversion systems, DC/AC conversion systems, solar and battery systems, etc.) should have some or all of the following system monitoring/alarms dependent on site classification:

- low input voltage shutdown alarm
- high temperature alarm
- rectifier failure alarm
- output overvoltage alarm
- fan failure alarm
- low voltage alarm
- circuit breaker action alarms?
- LVD action alarm
- generator start fail alarm
- generator run alarm
- generator fuel alarms

The provision of these alarms on a site classification basis is given below. Solar powered sites are to have solar array theft alarms fitted in all cases. Signage warning of the presence of these alarms should be installed.

Small DC Load Site	Type1	Type 2	Type 3	Type 4
Low input voltage shutdown alarm	✓	✓	~	~

Small DC Load Site	Type1	Type 2	Type 3	Type 4
High temperature alarm	✓	~	~	~
Rectifier failure alarm	✓	✓	✓	✓
Output overvoltage alarm	✓	✓	✓	✓
Fan failure alarm	✓	~	~	~
Low voltage alarm	✓	✓	✓	✓
Low voltage disconnect remote override	✓	~	~	~
Solar Array Theft Alarm (if applicable)	✓	✓	✓	✓
✓ - **Mandatory** ~ - **Optional**				

Table 5 - Small DC Load Site Alarms

Medium DC Load Site	Type1	Type 2	Type 3	Type 4
Low input voltage shutdown alarm	✓	✓	~	~
High temperature alarm	✓	✓	~	~
Rectifier failure alarm	✓	✓	✓	✓
Output overvoltage alarm	✓	✓	✓	✓
Fan failure alarm	✓	✓	~	~
Low voltage alarm	✓	✓	✓	✓
Low voltage disconnect remote override	✓	~	~	~
Solar Array Theft Alarm (if applicable)	✓	✓	✓	✓
✓ - **Mandatory** ~ - **Optional**				

Table 6 Medium DC Load Site Alarms

Large DC Load Site	Type1	Type 2	Type 3	Type 4
Low input voltage shutdown alarm	✓	✓	✓	✓
High temperature alarm	✓	✓	✓	✓
Rectifier failure alarm	✓	✓	✓	✓

Large DC Load Site	Type1	Type 2	Type 3	Type 4
Output overvoltage alarm	✓	✓	✓	✓
Fan failure alarm	✓	✓	✓	✓
Low voltage alarm	✓	✓	✓	✓
Low voltage disconnect remote override	✓	~	~	~
Solar Array Theft Alarm (if applicable)	✓	✓	✓	✓
✓ **- Mandatory** ~ **- Optional**				

Table 7 Large DC Load Site Alarms

Fixed Generator Sites	Type1	Type 2	Type 3	Type 4
Generator output High/Low Voltage	✓	✓	~	~
Generator start failure	✓	✓	~	~
Generator manual start	✓	✓	~	~
Generator enclosure high temperature	✓	✓	~	~
Lube oil pressure	✓	✓	~	~
High coolant temperature	✓	✓	~	~
Low coolant flow	✓	✓	~	~
Under/Over speed	✓	✓	~	~
Auto start/stop	✓	✓	~	~
Fire detection/suppression	✓	✓	~	~
Fuel Level Meter	✓ Continuous Scale	✓ Graduated Scale	~	~
✓ **Mandatory**		~ **Optional**		

Table 8 Generator - Site Alarms

All alarms should be communicated to a network operations centre.

Communications protocols should be either of the following:

- Ethernet 10/100 BASE-T
- SNMPv2

Communications protocols may be either of the following:

- SNMPv3
- Modbus
- DNP3
- CAN-bus
- Customer defined protocol

5.12 Earthing and lightning protection

Within a telecommunications shelter, an earth system may be required to perform different functions such as a protective earth, lightning protection, and a service or telecommunications earth.

0V bonding should be adopted as outlined in Section 6 of this document. The 0V bonding point must be clearly marked with a dedicated label. The bonding point must be demarcated and must be at an easily accessed location.

The earthing system must be designed and installed to match or exceed the designed fault current rating for the DC power system.

The earthing system must be selected so as to be fully compatible with any existing earth system in terms of materials and system performance (where performance exceeds NSWG standards).

All DC power system equipment (AC/DC conversion systems, DC/DC conversion systems, DC/AC conversion systems, Solar and Battery systems etc.) must be earthed in accordance with relevant Australian Standards, equipment manufacturers' recommendations and Customer requirements.

5.13 Power system accommodation

All DC power system equipment (AC/DC conversion systems, DC/DC conversion systems, DC/AC conversion systems, solar and battery systems, etc.) should be installed in dedicated equipment racks.

All equipment racks should be 19-inch racks. The height of the rack should be determined by the type and numbers of equipment to be installed.

Where 2V cells are proposed for use, custom racks to suit the batteries selected should be employed for use.

Where practical the DC power system rack should incorporate the rectifier assembly, control and monitoring unit, primary distribution and battery strings. Where necessary additional battery racks shall be provided.

The DC power system rack must be fully labelled detailing all equipment installed and appropriate warning labels/signs shall be affixed.

5.14 Solar array structures

Solar array support structures should be specified for each individual application and should be either standard items or purpose-designed and certified.

Solar array support structures may be any of the following in the following order for preference:

- Freestanding static arrays
- Tower or Pole-mounted arrays
- Building-mounted arrays

- Freestanding dynamic arrays (e.g. sun tracking)

Freestanding and shelter/building mounted are most desirable. Alternative support methods should only be considered for extraneous circumstances (e.g. extreme vegetation height/obstructions or where array has minimal impact to radio structure utilisation).

The design of solar array support structures is to be completed in accordance with the NSW Government telecommunications Authority "Guidelines for Telecommunications Structures" document.

The solar array structure should be designed to allow easy installation and transport to site. Cable supports and management should be taken into consideration in design and provided where deemed necessary.

Solar cells are to be fixed to the array structure using fixing methods acceptable to the Customer.

Solar power arrays and other system components are valuable and attractive items. As such, theft alarms and security fittings should be provided as specified by the Customer. Consideration should be given to employing tamper-proof fixing.

Ground-mounted solar arrays and support structures should, where deemed necessary, be placed behind security fences. Tower and pole mounted array structures must be placed so that they cannot be accessed without proper climbing aids such as elevated work platforms. When placed on an equipment hut roof, anti-climb devices must be fitted if the communications sites do not have a perimeter fence installed and the threat of theft is considered high enough to warrant further measures.

Solar array support structures should be constructed of materials either exhibiting low corrosion properties or treated with corrosion inhibiting coatings, processes or treatments to the satisfaction of the Customer.

Refer also to AS/NZS 5033.

5.15 DC power system equipment selection

All DC power system equipment (AC/DC conversion systems, DC/DC conversion systems, DC/AC conversion systems, solar and battery systems, protective devices etc.) must be:

- compliant with Australian Standards and all other relevant approvals
- supported by the manufacturer/importer/agent for an operational life in the field of 10 years unless otherwise specified
- documented in accordance with section 7 of this specification

When selecting equipment the following should be considered:

- redundancy should be as described in Section 9
- suitability for use in the local environment of the site
- ease of transport to and from site
- ease of installation
- ease of operation
- ease of maintenance

- environmentally sustainable construction (e.g. does not contain PCBs, potential for recycling, etc.)

6 Operations and Maintenance

To assist the operation and maintenance of the all systems supplied including throughout the equipment life cycle, the following documentation should be provided in a form acceptable to the Customer:

- operating handbook
- maintenance manual
- trouble shooting manual
- detailed list of recommended spares holdings
- as-built Installation drawings prepared in accordance with Customer guidelines for electrical installation drawings.
- certificate of compliance for electrical work
- test certificates
- material safety data sheets
- commissioning sheets
- recommended maintenance schedule
- guidance on safe and sustainable disposal

7 Disposal

All disposal work must comply with applicable Australian standards and codes of practices.

8 DC Power Systems- Recommendations

The tables within this section provide recommended solutions for Site Types 1 to 4, varying DC loads and power sources.

Mains Powered Site		DC Voltage System		Site Type 1					Site Type 2					Site Type 3					Site Type 4					Alarm and Monitoring
					Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source		
Load Demand	Site Access	12V	48V	Battery Back Up Time (Hrs)	Rectifier	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Rectifier	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Rectifier	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Rectifier	Minimum Batt. Strings	Generator Socket	Generator	
Small <1kW DC	Unrestricted	√	√	10	N+1	2	√	#	8	N+1	2	√	#	3	N+0	1	#	#	0	N+0	1	#	#	Table 5
	Semi Restricted	√	√	16	N+1	2	√	#	12	N+1	2	√	#	8	N+0	1	#	#	#	N+0	1	#	#	Table 5
	Restricted	√	√	36	N+2	2	√	#	36	N+1	2	√	#	24#	N+0	1	#	#	#	N+0	1	#	#	Table 5
Medium 1kW-5kW	Unrestricted	-	√	10	N+1	2	√	#	8	N+1	2	√	#	3	N+0	1	#	#	0	N+0	1	#	#	Table 6
	Semi Restricted	-	√	16	N+2	2	√	√	12	N+1	2	√	#	8	N+0	1	#	#	#	N+0	1	#	#	Table 6, Table 8
	Restricted	-	√	36	N+2	2	√	√	36#	N+2	2	#	√	24#	N+0	1	#	#	#	N+0	1	#	#	Table 6, Table 8
Large >5kW	Unrestricted	-	√	10	N+1	2	√	√	8	N+1	2	#	√	3	N+0	1	#	#	0	N+0	1	#	#	Table 7, Table 8
	Semi Restricted	-	√	16	N+2	2	√	√	12	N+1	2	#	√	8	N+0	1	#	#	#	N+0	1	#	#	Table 7, Table 8
	Restricted	-	√	36	N+2	2	√	√	36#	N+2	2	#	√	24#	N+0	1	#	#	#	N+0	1	#	#	Table 7, Table 8
# - Consultation between Customer and Service Provider																								#

Table 9: DC Powered Systems - Mains Powered Requirements

Solar Powered Site		DC Voltage System		Site Type 1					Site Type 2					Site Type 3					Site Type 4					Alarm and Monitoring
					Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source		
Load Demand	**Site Access**	**12V**	**48V**	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	
Small <1kW DC	Unrestricted	√	√	120	2	2	√	#	120	2	2	√	#	96	1	1	#	#	96	1	1	#	#	Table 5
	Semi Restricted	√	√	144	2	2	√	#	120	2	2	√	#	120	1	1	#	#	96	1	1	#	#	Table 5
	Restricted	√	√	168	2	2	√	#	144	2	2	√	#	144	1	1	#	#	120	1	1	#	#	Table 5
Medium 1kW-5kW	Unrestricted		√	120	2	2	√	#	120	2	2	√	#	96	1	1	#	#	96	1	1	#	#	Table 6
	Semi Restricted		√	72	2	2	#	√	120	2	2	√	#	120	1	1	#	#	96	1	1	#	#	Table 6, Table 8
	Restricted		√	72	2	2	#	√	72	2	2	#	√	144	1	1	#	#	120	1	1	#	#	Table 6, Table 8
Large >5kW	Unrestricted		√	60#	2	2	#	√	#	2	2	#	√	#	1	1	#	#	#	1	1	#	#	Table 7, Table 8
	Semi Restricted		√	60#	2	2	#	√	#	2	2	#	√	#	1	1	#	#	#	1	1	#	#	Table 7, Table 8
	Restricted		√	#	2	2	#	√	#	2	2	#	√	#	1	1	#	#	#	1	1	#	#	Table 7, Table 8
# - Consultation between Customer and Service Provider																								

Table 10: DC Powered Systems – Solar Powered Requirements

Hybrid Powered Site		DC Voltage System		Site Type 1					Site Type 2					Site Type 3					Site Type 4					Alarm and Monitoring
					Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source			Equipment Redundancy		Alternate Energy Source		
Load Demand	**Site Access**	**12V**	**48V**	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	Battery Back Up Time (Hrs)	Minimum PV Array	Minimum Batt. Strings	Generator Socket	Generator	
Small <1kW DC	Unrestricted	√	√	72	2	2	√	√	72	2	2	√	√	48	1	1	#	√	48	1	1	#	√	Table 5, Table 8
	Semi Restricted	√	√	72	2	2	√	√	72	2	2	√	√	48	1	1	#	√	48	1	1	#	√	Table 5, Table 8
	Restricted	√	√	72	2	2	√	√	72	2	2	√	√	72	1	1	#	√	72	1	1	#	√	Table 5, Table 8
Medium 1kW-5kW	Unrestricted	-	√	72	2	2	√	√	72	2	2	√	√	48	1	1	#	√	48	1	1	#	√	Table 6, Table 8
	Semi Restricted	-	√	72	2	2	√	√	72	2	2	√	√	48	1	1	#	√	48	1	1	#	√	Table 6, Table 8
	Restricted	-	√	72	2	2	√	√	72	2	2	√	√	72	1	1	#	√	72	1	1	#	√	Table 6, Table 8
Large >5kW	Unrestricted	-	√	#	2	2	√	√	#	2	2	√	√	#	1	1	#	√	#	1	1	#	√	Table 7, Table 8
	Semi Restricted	-	√	#	2	2	√	√	#	2	2	√	√	#	1	1	#	√	#	1	1	#	√	Table 7, Table 8
	Restricted	-	√	#	2	2	√	√	#	2	2	√	√	#	1	1	#	√	#	1	1	#	√	Table 7, Table 8
# - Consultation between Customer and Service Provider																								

Table 11: DC Powered Systems – Hybrid Powered Requirements

9 Definitions

Term	Definition
AC	Alternating Current
Anticipated initial full system load	DC system maximum demand at time of initial operation
Anticipated ultimate full system load	DC system maximum demand when all initial fitted equipment and all anticipated/ future equipment has been installed.
AS/NZS	Australian/New Zealand Standard
Autonomy	The number of days of operation of the power system without energy input from generators before exceeding the design maximum discharge depth of the battery.
Customer	New South Wales Government Representative
DC	Direct Current
Large DC Load Site	DC load > 5000W
Medium DC Load Site	DC load 1000W-5000W
MPPT	Maximum Power Point Tracking
NSWG	New South Wales Government
NSWTA	New South Wales Telco Authority
Plug in or portable Generator	An AC generator that is able to be taken to the site connected to the site's electrical distribution system by means of a generator inlet socket.
PV Module	Photovoltaic Module or Solar Panel constructed of Photovoltaic Cells
PV Array	Array of PV Modules. May consist of a single PV Module, a single string of serial connects PV Modules, or several parallel connected strings or sub-strings.
PWM	Pulse Width Modulation

Term	Definition
Restricted Access	For sites where access is required by extraordinary means such as helicopter, snow-mobile, walking access only in excess of 30 minutes.
Semi-restricted Access	4WD dry weather access, or likely to be cut off during weather or disaster events (flood, fire, earthquake etc.) or typically greater than 4 hours driving time of the Customers (or representative) deployment location or network support facility.
Service Provider	Designers, equipment suppliers and installers.
Small DC Load Site	DC load <1000W
Standby or Permanently connected generator	A permanently installed AC generator that is connected to the site's electrical distribution system by means of an automatic or manually operated generator change over switch.
Type 1 Site	Mission Critical: Application is critical to emergency response and management. Unavailability may impact on the management of a life and death situation.
Type 2 Site	Operational: Application is critical to performing daily operational tasks. Unavailability will not impact on the management of a life and death situation.
Type 3 Site	Business: Application is related to business or administrative activities.
Type 4 Site	Information: Application provides useful but not critical information for mobile unit daily tasks.
Unrestricted Access	Good all weather access track with right of way. Typically within 4 hours driving time of the Customers (or representative) deployment location or network support facility.
V	Volts
W	Watts
WHS	Work Health and Safety

Table 12: Terms and referencing

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