DOCUMENT CONTROL

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1 Introduction

1.1 PURPOSE

The *UWA Design and Construction Standards* (the *Standards*) outline UWA's expectations for its built forms in order to achieve consistency in the quality of the design and construction of those built forms. They are aligned with the UWA's Campus Plan 2010 planning principles and UWA's requisites for aesthetic appeal, maintainability and environmental sustainability, while ensuring that there is sufficient scope for innovation and technological advancements to be explored within each project.

The Standards are intended for use by any parties who may be involved in the planning, design and construction of UWA facilities. This includes external consultants and contractors, UWA planners, designers and project managers as well as faculty and office staff who may be involved in the planning, design, maintenance or refurbishment of facilities. These Standards also provide facility managers, maintenance contractors and other service providers with an understanding of UWA services in order to assist in the maintenance and operation of facilities.

1.2 SERVICES

The UWA *Design and Construction Standards for* ***Electrical Services*** (this document) are a part of *UWA Design and Construction Standards* set of documents (the Standards). The Standards are divided into the following service documents for ease of use, but must be considered in its entirety, regardless of specific discipline or responsibilities:

A Building and Architecture
B Mechanical Services
C Electrical Services (this document)
D Communication Services
E Hydraulic Services
F Security Services
G Fire Services and Fire Safety Engineering
H Structural Works
I Civil Works
J Irrigation Services
K Sustainability
L Vertical Transport

1.3 RELATED DOCUMENTS

1.3.1 University Documents

The Standards are to be read in conjunction with the following relevant University documents:

- UWA General Preliminaries Document
- UWA Specification for As-Constructed Documentation
- Relevant UWA planning and policy documents such as the *UWA Campus Plan*, *UWA Masterplan*, *Landscape Vision* and *Integrated Infrastructure Strategy*, *University Policy on Alterations to University Buildings*, etc.
- Relevant UWA operational and maintenance documents such as preferred vendors lists, room data sheets, operational and maintenance manuals, etc.
- Other documents as referenced within the *UWA Design and Construction Standards*.

1.3.2 Relevant Legislation

The planning, design and construction of each UWA facility must fully comply with current relevant legislation, including but not limited to:

- Relevant Australian or Australian / New Zealand Standards (AS/NZS),
- National Construction Code (NCC),
- Occupational Safety and Health (OSH) legislation,
- Disability Discrimination Act (DDA),
- Accessibility Aspiration Design Factors, and
- Local council and authority requirements.

1.3.3 Manufacturer Specifications and Data Sheets

All installation must be carried out in accordance with manufacturer specifications and data sheets to ensure product performance over its intended life and so as not to invalidate any warranties.

1.3.4 Project Specific Documentation

Requirements specific to a particular project, campus or other variable, will be covered by project specific documentation, such as client briefs, specifications and drawings. These Standards will supplement any such project specific documentation.

The Standards do not take precedence over any contract document, although they will typically be cross-referenced in such documentation.

Extracts from the Standards may be incorporated in specifications, however it must remain the

consultant's and contractor's responsibility to fully investigate the needs of the University and produce designs and documents that are entirely 'fit for purpose' and which meet the 'intent' of the project brief.

1.4 DISCREPANCIES

The Standards outline the University's generic requirements above and beyond the above mentioned legislation. Where the Standards outline a higher standard than within the relevant legislation, the Standards will take precedence.

If any discrepancies are found between any relevant legislation, the Standards and project specific documentation, these discrepancies should be highlighted in writing to the Associate Director Capital Works, Campus Management.

1.5 DEPARTURES

The intent of the Standards is to achieve consistency in the quality of the design and construction of the University's built forms. However, consultants and contractors are expected to propose 'best practice / state of the art' construction techniques, and introduce technological changes that support pragmatic, innovative design.

In recognition of this, any departures from relevant legislation, or the Standards, if allowed, must be confirmed in writing by the Associate Director Capital Works, Campus Management.

Any departures made without such written confirmation shall be rectified at no cost to UWA.

1.6 PROFESSIONAL SERVICES

For all works, it is expected that suitably qualified and experienced professionals are engaged to interpret and apply these Standards to UWA projects. Works cannot be carried out by unqualified and unlicensed consultants or contractors.

1.7 STRUCTURE OF DOCUMENT

This document is structured into 4 parts:

Part 1 Introduction (this Section)

Part 2 General Requirements – outlines the general requirements or design philosophies adopted at UWA

Part 3 Checklist for project team (if applicable) – checklist of items for consideration at various stages of a project

Part 4 Specifications (if applicable) – materials specifications and/or preferred lists for materials, processes or equipment used by UWA.

1.8 DEFINITIONS

For the purpose of this document, the following definitions apply:

Can: Implies a capability of possibility and refers to the ability of the user of the document, or to a possibility that is available or might occur.

May: Indicates the existence of an option.

Shall: Indicates that a statement is mandatory.

Should: Indicates a recommendation.

2 General Requirements

2.1 DESIGN CONSIDERATIONS

The design considerations are intended to facilitate the provision of functional spaces which are safe, comfortable and aesthetically pleasing.

Consistency

Combining electrical systems that vary in manufacturer and operating principles cause unnecessary complications during maintenance periods.

Within buildings, and across campuses, UWA seek uniformity in electrical systems design, effectively achieving coherence and compatibility across components both portable and fixed.

Functionality

UWA expect designers to understand the functions of the space and produce designs that practically serve the intended purpose of the space, permitting simplistic usability for every day operation and maintenance.

Determining logical functionality should involve consideration of several factors including special power requirements, overall cost and probability of expansion. Preference lies in the delivery of complete cost effective packages that refrain from over engineering and unnecessary expenditure.

Safety and Maintainability

Maintenance of electrical equipment and systems is crucial. Poor maintainability of equipment often leads to unexpected failures and lengthy power outages.

Reducing maintenance difficulties and optimising availability of products is essential. Design solutions shall prioritise safety at all stages from equipment selection through to construction and ongoing operation and maintenance.

Innovation

Incorporate contemporary technology and innovative engineering for aesthetics and functionality. Designers should perform life cycle analysis on systems to ensure that selected equipment will last the expected life of the building and replacement equipment remains available throughout.

2.2 SPARE CAPACITY

Supply and distribution systems shall have capacity to deliver the project maximum demand at quality parameters to within tolerance of the end use equipment specifications, without exceeding the manufacturer's ratings for reliable operation of any system component. Systems should have capacity to accommodate load growth as defined by UWA.

Electrical maximum demand for particular spaces such as laboratories and data facilities tend to change in size throughout the life of the building. Provide electrical infrastructure capable of accommodating any expansion.

Provision shall be made for spare capacity in components of the electrical system. As a general rule, a minimum of 25% spare capacity should be allowed for when sizing electrical equipment such as:

- Power Transformers and Switchgear
- Feeder Cabling
- Submains Cabling
- Main Switchboards and Distribution Switchboards (including Mechanical Services Switchboards)
- Cable Containment Systems
- Sub-circuit cabling
- Generators
- UPS Systems

2.3 REDUNDANCY AND CRITICALITY

Redundancy is the duplication of critical electrical components of a system with the intention of increasing overall reliability. Redundancy contributes to reducing the possibility of complete power outages due to a failure of a single piece of equipment such as a power transformer.

All facilities shall have at least reliability and redundancy in the provision and delivery of engineering services to comply with statutory specifications and UWA infrastructure requirements.

Where equipment within a space is considered to be critical to the operation of the space, redundant infrastructure, back-up power supplies and the like shall be included within the design. Assessment of a space's functionality should provide clarity on whether redundant equipment is required.

2.3.1 General Provisions

It is recognised that availability of power is becoming increasingly important to University needs, including the need to implement "alternative procedures" during a period of loss of Utility power supply. As such all new buildings or major refurbishments shall incorporate a separate Essential power distribution system with back-up by Standby Generator. Depending on specific project needs there may also be a requirement for a UPS system to back up critical loads, in addition to the Standby Generator. Services within a building that are required to be connected to Essential power should be confirmed for particular project requirements, but include the following as a minimum:

- Security (access control, CCTV, etc.)
- Fire – Electrical
- Fire – Hydraulics (Irrigation)

- Smoke management
- BMCS
- Communications/ IT equipment
- Lifts
- Critical Research

All services provided for life-safety considerations shall be connected to the Essential supply system. All systems/ services provided for security reasons shall be connected to the Essential supply system. Where services systems are provided with battery back-up to satisfy regulatory requirements, power supply to these systems shall be connected to the Essential supply system.

Assessment of Essential loads shall identify spare load capacity for specific future load growth, in addition to overall spare capacity allowances.

2.3.2 General Offices

General office spaces within UWA do not normally contain critical equipment; therefore they rarely require redundant power supplies for general lighting, power and plant. Assessment shall be made for project specific requirements.

2.3.3 Teaching Spaces and Lecture Rooms

Similar to office spaces, teaching and lecture spaces generally do not require critical power supplies for general lighting, power and plant. Assessment shall be made for project specific requirements.

2.3.4 Laboratories

Some of the functions within UWA laboratories may require a diverse power supply, redundant supply routing, high levels of availability, or secure power provisions. Criticality of power supplies in laboratories is to be determined in the early design phase specific to each project.

2.3.5 Data Facilities and Communications Rooms

These facilities are usually of high criticality, requiring diverse redundant power supplies for servers and critical data storage equipment, and support services. Assessment shall be made for the required level of availability and redundancy during the early design phase specific to each project.

2.3.6 Plant Rooms

Plant rooms and associated equipment provide support to the functions within the particular building and generally house safety services plant and control gear that is critical to facilitate safe evacuation during an emergency. These spaces may also house plant that is critical to specific building functions (such as research). The criticality of power supply to equipment in such areas should match the requirements for the utilisation/ occupation within the building. Power supplies designed for plant room equipment should be in line with *Section 2.12.7* (Essential Services) of this document.

2.4 ENERGY CONSERVATION AND SUSTAINABILITY

Energy conservation is a fundamental design principle within UWA. Electrical works shall comply with the requirements of the *National Construction Code (NCC)* and UWA *Design and Construction Standards – Sustainability*.

Consultants shall co-ordinate with the broader design team to consider ecologically sustainable design (ESD), including environmental impacts and energy efficiency.

Where an Independent Commissioning Agent (ICA) is appointed as part of the project team, coordinate to ensure the requirements of the ICA are specified and that the contractor's works are detailed, constructed, tested, commissioned and tuned in accordance with the project requirements.

2.5 STANDARDS AND CODES

New electrical systems and modifications must comply with all relevant Australian Standards, *National Construction Code*, *WA Electrical Requirements*, *WA Electricity Act 1945* and *Work Health and Safety Requirements (Public Buildings) Regulations*.

Where Australian Standards are not available, relevant IEC and/or ISO standards shall be referred to.

Applicable Standards include (but are not limited to) those listed within the *References* section of this document. Standards listed should be reviewed for current versions and additional amendments.

2.6 INFRASTRUCTURE

2.6.1 Load Profile Development

Due consideration shall be given to the accurate development of the project load profile.

The adequacy of supply shall always be assessed prior to proceeding with any electrical design. An increase in the maximum demand above that currently covered in the existing University network (and also possibly more than allowed by Western Power) shall be requested and approved through the University (including where relevant application to Western Power) as part of the design.

2.6.2 Electricity Supply

Crawley Campus

The UWA Crawley Campus power supply is provided by Western Power via 3 Step Down 5MVA 11/6.6kV Transformers. The supply voltage to UWA's HV Network is 6.6kV and terminates at 3 HV Switchboards (point of common coupling). The 3 HV Switchboards are interconnected through bus-tie cables.

The 6.6kV power supply is distributed around the campus via four rings. At each of the Distribution Substations on the rings, the power supply is stepped down from 6.6kV to 400V through Distribution Transformers and then distributed to Main Switchboards, Distribution Boards and other loads.

Other Campuses

The electricity supply for all other campuses is to be provisioned in line with the specific requirements for the project.

2.6.3 Shutdowns

Electrical supply shall not be disconnected or isolated without prior notice and approval. Notice periods are subject to University's academic calendar (to take into account activities such as exams), but also subject to change and should be determined for specific project requirements. As a general rule, the following minimum notice periods should be allocated: long term planning – 2-6 months; confirmation of project timetable – 2 weeks; immediate requirements – 48 hours.

2.6.4 Temporary supply for construction purposes

The temporary supply of electricity to a construction site is the responsibility of the building contractor and is inclusive of temporary wiring and distribution boards.

The building contractor shall determine the appropriate point and method of connection and submit for approval. Final connection of the temporary supply shall be witnessed by UWA.

2.6.5 Access to Electricity Infrastructure

Electrical infrastructure (including substations, switchrooms, switchboard cupboards, external equipment cabinets and plant) shall be secured to prevent unauthorised public access, and permit controlled maintenance access. Facilities for emergency egress shall be provided at all times.

Door locking hardware and associated equipment selections shall comply with *UWA Design and Construction Standards – Security Services*.

Specific key patterns for electrical equipment:

- HV switchrooms, externally mounted HV equipment, transformer enclosures – restricted "HV Key".
- LV distribution panels within buildings and stand alone cubicle distribution panels – "ED6 Key".
- Switchrooms, switchboards, plant rooms and enclosures – "EM Key".

2.7 ELECTRICITY METERING

Metering shall be provided to enable effective monitoring of the energy use throughout the building. In all critical areas (as determined by the functions within the space), power quality metering shall also be provided. Meters shall be connected to the Revata energy management system. Refer *Section 5* for further information on integration with Revata.

2.7.1 Authority Tariff Metering

Assessment shall be made whether main switchboards connected to a substation should be fitted with Electricity Supply Authority Metering devices within the switchboard enclosure.

2.7.2 Private Tenant Sub-Metering

Sub-metering should be installed to enable monitoring of individual energy usage for all tenants, where applicable.

Sub-meters and CT's shall be of the same quality as Authority tariff metering devices.

Meters shall be capable of measuring Voltage (V), Current (A), Energy (kWhr), and Power Factor (%). All meters shall be connected to Revata.

2.7.3 Energy Management, Power Quality and ESD

Metering must be provided in accordance with the current version of the NCC. Additional metering, including capturing and processing of data, shall be provided in accordance with sustainability initiatives as identified within the *UWA Design and Construction Standards – Sustainability* and project specific requirements.

Meters should be setup to measure Voltage (V), Current (A), Frequency (Hz), Energy (kWhr), Power (kW), Total reactive power (kVar), Total apparent power (kVA), Power Factor (%), total harmonic distortion (THDi & THDv) and maximum demand (kW). The time frequency of recording should be in accordance with ESD requirements.

2.8 HIGH VOLTAGE DISTRIBUTION

2.8.1 General

HV infrastructure shall be designed with consideration of ease of maintenance and installed in

accordance with Australian Standards, *NCC* and the Western Australian Distribution Connections Manual.

The various aspects of the HV distribution system shall be coordinated with architectural design requirements, fire protection strategy and security requirements. Refer *UWA Design and Construction Standards* for other services, in particular *Building and Architecture*, *Mechanical Services*, *Fire Services* and *Security Services*.

Where there are high voltage transformers and switch gear on site these shall:

- Either be housed in buildings or structures remote from student and staff areas or be located in a fire isolated part of the main building
- Comply with the requirements of the *NCC* and Statutory Authority requirements for fire separation and/or isolation from buildings
- Include separation for redundancy of supply where required for critical loads
- Only be accessible by authorised persons
- Be installed in environments where it can be accessed safely for operation and maintenance during the most extreme credible risk management conditions, e.g., restoration of services during a storm
- Be provided with lighting served from the essential electricity supply
- Be provided with power to control switching served from the essential electricity supply.

2.8.2 HV Cable

HV cable routes for new installations shall be determined through consultation with UWA.

All trenching or ground penetration for HV cables shall be coordinated with all other in-ground services. Trenching, back-filling and surface treatment shall comply with *UWA Design and Construction Standards – Civil Works.*

New HV cables shall be installed underground or in service tunnels where available. For new HV cable routes, consideration shall be given to utilising the dedicated service corridors which have been established on site.

Cable distribution paths for both HV and LV distribution systems shall include diverse routing for redundancy of supply where required for critical loads.

HV Network Rings

HV network feeder cabling shall be 12.7/22kV 3 x 1c (triplex) 400mm^2 aluminium XLPE/PVC, or as confirmed with UWA for the specific position in the network.

The HV network feeder cable shall be buried to a minimum of 900mm below finished ground level or laid within dedicated trenches.

The HV network feeder cable can be installed direct buried or within conduit, however must be installed

within conduit for under road crossings.

HV Transformer Cable

HV transformer cabling shall be 12.7/22kV 3 x 1c (triplex) 95mm^2 copper XLPE/PVC.

The HV transformer cabling shall be buried to a minimum of 900mm below finished ground level or laid within dedicated trenches.

The HV transformer cable shall be installed direct buried or within conduit, however must be installed within conduit for under road crossings.

2.8.3 HV Switchgear

Ring Main Units

HV Switchgear shall be rated at 12kV and have a minimum fault rating of 25kA/1s.

The HV Switchgear should utilise vacuum technology as the dielectric and circuit-interrupting medium. Gas insulated (SF_6) HV Switchgear may also be considered as an alternative.

HV Switchgear shall be metal clad, modular and extensible. Extensibility shall be provided at one end as a minimum, to allow for additional functional units to be added in the future.

All HV Switchgear shall be designed and constructed to Australian Standards (or equivalent international standards) providing complete safety to the operator by ensuring full arc fault containment. All HV Switchgear is to be provided with Type Test Certificates by the manufacturer.

The typical general arrangement of HV switchgear shall consist of the following functional units:

- x Network Isolator Switches (typically 630A)
- N x Transformer Circuit Breakers (typically 200A) (where N = number of Transformers)
- +1 x Transformer Circuit Breakers where required for redundancy or future expansion

Provision shall be made for the HV switchgear to be operated remotely but without removing local switching ability.

The HV Switchgear shall also be fitted with motorisation on the Network Isolator Switches. Equipment shall be compatible and integrate with the BMCS for remote operation.

Transformer Circuit Breakers do not require motorisation unless deemed necessary for the design.

Protection Relays

Protection Relays on Ring Main Units shall be microprocessor based and self-powered. Auxiliary powered relays (e.g. DC) can also be considered as an alternative, if deemed necessary for the design.

Protection Relays shall be capable of providing the following protection functions:

- Feeder Protection Functions (IEEE/ANSI) – full selectable range of Instantaneous and IDMT for Over Current and Earth Fault.

- Configurable Curve Types (IDMT Stages) – full selectable range of Instantaneous through to Standard Inverse.

2.8.4 HV Power Transformers

Dry Type Transformer (Cast Resin)

Power transformers and associated equipment shall be designed to meet load requirements for continuous operation under normal site conditions (AN) plus spare capacity for future use. Air forced cooling (AF) shall be considered, if deemed necessary for the design.

Consideration shall be given to noise requirements specified in Australian Standards.

Transformers shall be specified as having dual primary voltages of 6.6kV & 11kV to allow for future upgrade of the system voltage from 6.6kV to 11kV.

Minimum degree of protection for power transformers shall be IP66 for outdoor applications and IP23 for indoor applications.

Oil Type Transformer

Oil type transformers are not preferred, unless deemed absolutely necessary for the design. Where the use of such transformers is unavoidable, additional measures will need to be adopted and approved.

2.8.5 Earthing of HV Systems

All earthing shall be designed, installed and tested in accordance with *AS 2067* and *AS/NZS 3000*.

2.8.6 HV Switching

All HV switching shall be undertaken in conjunction with UWA nominated authorised electrical officers.

Prior to any switching on campus, a switching programme must be approved by UWA authorised representative. All switching operators shall be competent, licensed and have completed a Western Power approved High Voltage Switching Course.

Refer to Campus Management for UWA switching policy.

2.8.7 Substations

The design of substations shall conform to the requirements of all authorities, regulatory bodies and Code/ Standards.

A single line diagram of the high voltage system shall be mounted in the switch room and show:

- Source of supply

- Extent of the system
- Ownership interfaces of the equipment
- Supply Authority contact person details
- Ratings of protection
- Ratings of cables
- The location of any earthing equipment needed for the switchgear
- The location of any standard switching schedules associated with use and maintenance of the switchgear
- The location of safety and test equipment needed for switching
- Contact details of persons authorised to carry out, and qualified to perform the switching.

Accessibility

Provision shall be made to enable removal and replacement of equipment such as transformers and switchgear for maintenance by means of adequately sized doors and removable panels. Access covers can also be considered to allow for lowering/ lifting the equipment through the roof, if deemed necessary for the design.

Cable Conduits & Pathways

Design layout should include sufficient consideration of the routing and positioning of heavy mains cables, to enable adequate space for access and installation of future extensions without need for reworks.

Conduits shall be sized to conform to *AS/NZS 3000* and to facilitate pulling cables with ease.

Cable pits and trenches shall be sized to facilitate the specified bending radii of the cables and permit cable jointers to work within them.

Concrete Cable Trenches

The size of cable trenches and pathways shall be large enough to facilitate maintenance activities and prevent unnecessary bunching of cables.

Direction changes within trenches shall be large enough to allow for the bending radius of heavy submains cabling.

Trench covers shall be constructed of a material that is easily removed by two maintenance personnel. The top of the covers shall finish flush with the finished floor level as to avoid tripping hazards.

All concrete cable trenches shall be tanked to avoid ingress of ground water and designed to allow for drainage to prevent flooding.

Ventilation/ Air conditioning

Adequate ventilation/ temperature controls shall be provided to ensure that equipment does not exceed maximum ambient temperature ratings of all equipment under maximum operating conditions.

Natural ventilation shall be considered primarily, though where impractical, shall be by means of air conditioning and/or exhaust fans. Mechanical ventilation/ conditioning equipment shall be controlled locally and be monitored by the BMCS.

2.9 BACK-UP POWER SUPPLY

Electrical designs shall be assessed for the need of back-up power supplies. Integration of back-up power may include redundant HV network rings and equipment, uninterruptible power supply (UPS) systems and generators.

Selection of a type of back-up power system will call for assessment of project specific functionality. Examples of where back-up power supply may be required are:

- Communications Rooms and Data Facilities
- Laboratories that require critical power supplies
- Plant rooms containing life safety services

The design and installation of diesel generators, battery bank UPS units and automatic transfer switches (ATS) is not mandatory unless specified for the project by statutory regulations for life safety services.

Back-up power supply system alarms shall be integrated to the BMCS for monitoring.

2.9.1 Transfer Switching

Assessment shall be made to determine the type of switching for connection of alternate power sources that is appropriate for the project.

Manual transfer switches would be considered for connection of alternate power for maintenance involving interruption to non-critical loads; for example, connection of a portable generator via a plug connection.

Open transition automatic transfer switching would be considered for non-attended operation and connection of critical loads. In this instance, the re-connection of mains power would involve a break in the power supply and would be appropriate where this momentary loss of power does not compromise the operation of connected equipment. In addition to occurrences of loss of mains power, this momentary loss of power to a critical load would occur during periods of testing the operation of the alternative power supply arrangement.

For any load where such a momentary loss of supply would have a deleterious effect on the performance or operation of the equipment, then the more appropriate form of switching would be a closed transition ATS system.

Where the capacity of the alternate power source is lower than the normally connected load, load shedding procedures shall be incorporated into the distribution design, with the priority of load retention

in accordance with University operational requirements.

2.9.2 Standby Generators

Standby generators shall comply with *ISO 8528* with consideration of the following:

- Location to be installed
- Noise control measures
- Fuel storage capacity determined from location of the generator and availability for refuelling
- Exhaust flue placement, including coordination with building air intakes, etc.
- Ventilation requirements
- Controls and monitoring
- Alarms and security requirements
- Cabling

Generators shall be supplied and installed complete with all controls, safety devices and auxiliaries to provide safe and unattended operation.

Generally, generators shall be sized such that the maximum connected load is <80% of the generator rating and minimum connected load is >50% of the generator rating. Additional future load shall be considered when sizing the generator.

Where transfer switching forms part of the distribution of power across the campus, an ATS logic procedure diagram shall be displayed in the associated switch room for maintenance contractor reference.

Standby generators shall have fuel supply arrangements that will keep them in operation for the longest credible normal supply outage as determined by risk analysis or as nominated by UWA.

The fuel system shall have provision for emptying fuel tanks so that fuel can be replaced if fuel condition monitoring indicates quality has deteriorated.

Generators shall be installed in an environment where they can be serviced and maintained in all conditions.

Routine testing shall be configured to be undertaken on live building loads, but without disruption to the normal operation of the facility. In addition, provision shall be made for a portable load bank to be connected to the generator via a permanent connection point rated to at least 110% of the generator rating. The location of the load bank and interconnecting cabling shall not impede normal occupation of the building.

2.9.3 Uninterruptible Power Supplies (UPS)

UPS power supply provisions shall be assessed according the criticality and functioning of the load, as appropriate to the specific needs of each project.

All UPS systems shall be configured for coordinated distribution of power, required levels of redundancy, autonomy time to suit equipment shutdown or alternative longer term power back up and diverse power flow where required. Determine the appropriate selection of centralised versus distributed systems, fully on-line versus standby operation, positioning of large and potentially heavy plant, energy storage options, system maintainability and functionality.

A complete UPS maintenance plan shall be developed and agreed upon in consultation with UWA.

Static UPS

Static UPS units shall be designed and installed in accordance with the relevant equipment manufacturer's specifications and relevant Australian Standards. Battery selections shall be based on contemporary technology with due consideration of power density, fire rating and ventilation requirements, whole of life costs and material disposal strategy at end of life. Battery monitoring systems connected to BMCS should be considered and applied as agreed with the University.

UPS system batteries shall be housed in a suitably designed rack or enclosure. All battery enclosures are to be designed to allow adequate space for maintenance activities. Enclosures shall be positioned in a room to allow for sufficient ventilation, cooling and maintenance.

Flywheel energy storage systems shall be positioned to suit the structural design of the building. Adequate access for removal shall be provided.

All equipment shall be provided with adequate clearances to allow safe exit in the case of an emergency.

Where a standalone rack mountable UPS system is to be introduced, heat dissipation shall be considered especially for small switch rooms, comms rooms, cabinets and enclosures. Where the ambient temperature is likely to exceed 25°C a ventilation or air conditioning system shall be installed.

Diesel Rotary Uninterruptable Power Supply (DRUPS)

Assessment should be made for the feasibility and requirement of DRUPS systems. Where factors such as overall system efficiency, footprint size and length of technical lifetime are of high priority, DRUPS may be used.

For UPS systems utilising flywheel energy, the same guidelines apply as for generators.

Noise levels generated by DRUPS systems shall be limited by the use of acoustic treatment.

UPS Maintenance

A copy of the manufacturer's specifications and commissioning report including test values established at setup shall be included in the Operation and Maintenance manuals and in the system's enclosure.

UPS loads should be provided with a manually operated bypass supply connection (external to the UPS) to maintain operation of all loads during UPS plant maintenance. Such bypass shall be switched without break to the loads.

2.10 RENEWABLE ENERGY SOURCES

Where renewable energy sources (for example, solar PV systems) are to be incorporated, all regulatory protocols required shall be incorporated into the project, including all necessary consultation with and obtaining the approval of UWA.

2.11 SWITCH ROOMS

2.11.1 Spatial

The size of switch rooms and switchboard cupboards, ducts or enclosures, shall be sufficient to accommodate the switchboard, additional associated electrical equipment and the free movement of maintenance personnel carrying out maintenance activities. Switchboard rooms and cupboards must be sized to the requirements of *AS/NZS 3000*, including the use of two points of egress where required.

Provide adequate access and egress pathways, not only for the switch room itself but for surrounding emergency egress areas that may be affected by the switch room positioning. Such areas may include lift lobbies/ openings, emergency exits into stairwells and narrow corridors

Allowances shall be made for free movement of trolleys and lifting aids where replacement of electrical equipment may be required.

Ceiling height or space between the top of switchboards and under soffit shall be adequate to allow for overhead cable containment, sufficient bending radius of cables and ventilation/ air movement.

If the building is to be extended in the future, the switch room shall be of adequate size to enable the switchboard to expand on both ends.

Space shall be considered for potential auxiliary equipment, such as metering, harmonic filtration, power factor correction units, external lighting control units and general light and power distribution boards, plus items which may be required as part of future expansion.

2.11.2 Ventilation

Switch room ventilation shall be by means of louvered vents, air conditioning and/or exhaust fans. Special consideration must be made for ventilation of equipment that produces excessive heat such as UPS systems, Harmonic Filtration and Power Factor Correction Units. All air intakes shall be provided with filters to avoid dust build up in the rooms.

Ventilation of switch rooms housing several large switchboards and items of electrical equipment shall be locally controlled and monitored by the BMCS.

2.11.3 Fire Protection

Fire protection systems for switch rooms shall be designed in accordance with relevant Australian Standards and *UWA Design and Construction Standards – Fire Services*.

For switch rooms and switchboard enclosures that contain switchboards feeding Essential services or Life Safety services, the room shall be constructed with smoke and/ or fire rated walls to comply with the requirements of NCC, plus any other provisions as required by the Fire Engineer.

2.11.4 Security

Doors shall be fitted with the appropriate security equipment to prevent unnecessary entry by unauthorised personnel, while allowing for exit from within the switch room without the use of a key. Doors shall open outwards in the direction of egress from inside the switchroom.

The door locking system should comply with the UWA master keying system and be integrated with the building security system. Refer *UWA Design and Construction Standards – Security Services*.

Emergency egress shall be provided at all times.

2.11.5 General Light and Power

Power supply for general lighting and power within the main switch room, other large switch rooms and Essential services plant and switchboards shall be derived from the Essential services supply section in such a way that allows for the safe operation of equipment within the room during times of electrical shut-down (or failure).

At least one general power outlet shall be installed within each switch room and electrical plant room/ area for use of miscellaneous equipment or tools such as hydraulic crimpers, vacuum cleaners, battery charger, etc.

2.11.6 Concrete Cable Trenches

Cable trenches for switch rooms shall match the requirements as noted previously for HV rooms and substations.

2.11.7 Signage

Doors of main switch rooms and ducts, cupboards and enclosures shall be fitted with UWA standard door nameplate detailing the room number and name. Refer *UWA As-Constructed Documentation Specification* for room numbering.

HV substation and switch room doors must contain the correct signage in accordance with *AS 1319*. Signage on doors shall comprise the words ‘DANGER’, ‘High Voltage’ and ‘Authorised Persons Only’.

2.12 SWITCHBOARDS

2.12.1 General

This section applies to Main Switchboards (MSB), Main Distribution Boards (MDB), Distribution Switchboards (DB) and Other Services Switchboards, such as Mechanical (MSSB), Fire Pumps (FSSB), Hydraulics Pump Systems (HSSB) and the like.

Internal wiring shall be neat without unnecessary crossing of cables. Cable looms shall be tied regularly and secured to cable basket or tray to avoid cable sag and free movement.

Any switchboard, to which HRC fuses are fitted, shall also contain a fixture in which 3 spare fuse cartridges can be stored.

2.12.2 Form of Separation

The Form rating of each switchboard shall be determined after examination of the criticality of the loads it is serving. Assessment shall also be made of the ability to sustain and isolate power to switchboard sections without the need to isolate the entire unit. For applications where switchboards supply critical loads that do not have redundant power supplies, a higher form rating shall be selected to facilitate maintenance and modification activities without having to isolate the switchboard. Switchboards powering Essential services should be separate from other services and rated to at least Form 3b.

2.12.3 Degree of Ingress Protection

The degree of protection shall be determined after assessment of the proposed location of the switchboard. The switchboard shall be adequately protected from the ingress of solids and liquids. Generally, switchboards should be IP42 for indoor applications and IP56 for outdoor applications and plant rooms.

2.12.4 Inspection and Testing

UWA reserves the right to carry out inspections during the course of construction and to instruct specific tests to be undertaken on each completed switchboard. A statement to this effect must be included in all specification documents.

The following sequence of inspections and tests is to be carried out by UWA representative:

- Review of switchboard drawings after selection of switchboard manufacturer but prior to commencement of manufacture
- Factory inspection when the switchboard is substantially assembled but before painting and finishing has been started

- Factory inspection before the finished switchboard leaves the works including ductor, primary and secondary current injection and hi-pot testing of all automatic equipment on the switchboard
- A thorough on-site inspection of the whole switchboard including all connections to it before the board is energised
- During the highest load time-frame of the defects liability/ warranty period a thermographic survey shall be carried out and a written report shall be submitted to Campus Management. A written report shall be submitted to UWA.

2.12.5 Main Switchboard

The main switchboard shall be designed for the specific project requirements.

The main switchboard shall be constructed of high grade 2mm sheet steel.

Hinged panels shall be suitably stiffened and fitted with lift-off hinges. Large lift-off panels are not favoured, though if unavoidable, must be fitted with appropriate D handles for ease of removal. Such panels shall have a means of support such as guide studs or support ledge for use while fixing screws are being fastened.

Escutcheon covers and hinged panels shall be fixed in place with knurled headed screws or a similar fixing able to be loosened without the use of a tool.

The switchboard shall be mounted on a welded, galvanised channel that is pre-drilled to allow for hold down bolts.

Provide type tested assemblies that are identifiable with respective Type Test Certification.

The main switchboard may have front or back access.

Provision shall be made for connection of future submain circuits using a variety of different circuit breaker sizes, with overall capacity as noted in *Section 2.2* (Spare Capacity) of this document.

Cable containment leading to and within the main switchboard shall be sized to accommodate cables for future expansion.

For all switchboards located in ducts, cupboards or rooms, the external finish shall be two coats of gloss enamel paint in a colour similar to *Australian Standard 2700* Colour No ”Doeskin”, for all non-essential circuits. Internal finish colour should be gloss white. Where the switchboard is exposed to view and the colour scheme of the building requires a different switchboard colour, the actual selection shall be to UWA’s requirements and approval. For switchboards serving essential or critical loads, or requiring clear identification for reasons of functionality or operation, an alternative colour scheme shall be developed to UWA’s requirements and approval.

A thorough on-site inspection of the whole switchboard including all connections is to be carried out before the board is energized.

2.12.6 Busbars

Busbars shall be of adequate dimensions to accommodate the power load to be carried by the switchboard throughout the anticipated life of the building. Consideration for larger bars installed in the first instance may save a costly rebuild of the switchboard if the building is ever extended.

Care should be taken to ensure that the busbars are rigidly supported. All bolts on busbar systems shall be correctly tightened and checked. All bolts must be high tensile strength.

Busbars in open sections of a board such as the connections to the rear terminals of switches or switchgear shall be insulated with phase-coloured insulation. Busbars shall not alter in cross sectional area along the entire length of the installation. No busbars or joints shall be accessible to be touched.

2.12.7 Essential/ Safety Services

Within this document, Essential services refers to not only Safety Services as defined in AS/NZS 3000, but also the electrical installation of building services that are essential for the safe operation of the safety services consisting of fire detection, warning and extinguishing systems, smoke control and management systems, evacuation systems and the safety of persons using lifts. In addition, Essential services include research equipment which requires power continuity, communications and IT services that support building functions and equipment used within the facility.

Essential services electrical infrastructure is intended to ensure that electricity supply is not inadvertently disconnected from electrical equipment that is required to operate during emergency conditions.

Essential services equipment also includes electrical items referred to as ‘emergency equipment’ in the *NCC*.

A section of the main switchboard shall be designated for supplying power to Safety services. These services shall be connected to the line side of the main switch.

Power and lighting within main switch rooms at UWA shall be derived off Essential services supply to facilitate a safe working environment during shut-downs and outages.

Socket outlets and LV light switches connected to Essential supplies or UPS supplies shall be distinguishable from non-essential services. This may be achieved by providing coloured outlets (such as Red for Essential and Blue for UPS) and appropriate labeling.

2.12.8 Other Services Switchboards

For general design criteria for other services switchboards (MSSB and the like) refer to *Section 2.12.5* (Main Switchboards) of this document.

Metering of MSSBs

Energy management and power quality submeters shall be installed to other services switchboards throughout. Refer *Section 2.7* (Metering) of this document.

All submeters shall form part of and be connected to the project wide management system.

Metering Test Links

A GEC metering strip shall be incorporated behind the front of the switchboard with the meter wiring passing through it for simple attachment of recording instruments. The GEC test Terminal Blocks will be supplied to the switchboard manufacturer from UWA stocks.

Connection of the test link shall be in accordance with UWA *Standard Drawing 206/E/24* (available from Campus Management).

The end, face or top of the switchboard cabinet shall be fitted with a swing-open cover approximately 100mm^2 situated close to the test link to allow access for cables between recording instruments and test links.

2.12.9 Distribution Switchboards

Where practicable, distribution switchboards shall be located in circulation spaces, corridors or foyers in a secure dedicated cupboard or room. Consideration shall be made to locate DB's close to vertical services risers. Switchboards shall be positioned to avoid subcircuit cabling cross fire zone boundaries.

Ceiling access panels (minimum size 600x600mm) shall be installed close to the distribution board to facilitate easy access for installation of additional cabling.

Completed circuit schedules shall be provided to UWA and incorporated in Operations and Maintenance manuals.

Size and Construction

Distribution switchboards shall be designed with large cable zones and equipment space. DB's shall be sized with 50% spare circuit capacity and electrical demand.

The distribution switchboard and switchgear shall be rated at a minimum fault level of 10kA for 1 second.

All distribution boards shall:

- Comprise single main isolating switch with shrouded terminals
- Be constructed from sheet steel (except where located outside, refer to later clause)
- Have gland plates for top and bottom entry

The main isolating switch shall not interlock with the escutcheon cover.

Numbering of Distribution Boards and Circuit Breakers

Each distribution switchboard shall be clearly numbered. The numbering system is to be self-evident and consistent across the project, with no possibility of duplication of numbers or confusion between the switchboard position and the area served, for example:

- All distribution boards on any one level, supplied with power directly from the main switchboard, are to be consecutively numbered, the switchboard number following a decimal point after the level designation, viz B.1, B.2, G.1, G.2, 1.1, 1.2 etc.
- Where a building has a separated wing or a number of wings, each wing, rather than a level designation may be used, viz A1, A2 or LT.1, LT.2 etc.

Where a switchboard is supplied with power from an upstream distribution switchboard, it shall bear the originating switchboard's designation followed by its own identifying numeral, viz G.1.1 or 1.2.1. By this means the number of the switchboard will describe the origin of supply. This numbering would apply even if a sub-distribution board on one level supplies power to a board on another level.

Both the phase and circuit numbers of each circuit breaker should be clearly shown on the distribution board escutcheon. The numbering sequence should be Red 1, White 1, Blue 1, Red 2, White 2, Blue 2 etc.

This can best be achieved by coloured indicating buttons (IPA markers) mounted adjacent to each circuit breaker.

Circuit Schedule

A clear, legible, typed circuit schedule on white A4-size cardboard shall be installed in a metal holder either adjacent to or attached to the inside of the door of each distribution switchboard. A copy of the circuit schedule shall be provided to UWA Campus Management electrical staff.

In a new building, the room numbers and designations shall be checked as these may change during the course of construction.

Circuit Breakers and RCD's

Due care shall be taken to ensure circuit breakers of the same manufacturer are selected to achieve discrimination for required prospective fault levels. The use of cascading protection is to be avoided.

Residual Current Devices (RCD's) should be rated at 30mA.

Integrated RCD's and circuit breakers (RCBO's) should be used for circuits requiring RCD protection. They shall be arranged in the distribution board so that the test button is accessible without the need to remove covers. Remote positioning of RCD adjacent to a switched socket outlet (SSO) is not considered acceptable.

Air circuit breakers shall be used for loads equal to or greater than 1200 Amps.

Moulded case circuit breakers shall be used for loads equal to or greater than 100 Amps

Miniature circuit breakers should be used for loads less than 100 Amps

Trip time testing shall be carried out when a new RCD is installed and shall be recorded in the Operation and Maintenance manuals.

2.12.10 Externally Mounted Switchboards

Where switchboards are mounted external to buildings and subject to weather or other adverse conditions, the outer enclosure shall be fabricated from 3mm gauge marine grade aluminium with a sanded finish. Colour shall be “Doeskin”.

Door locks shall be stainless steel.

2.13 POWER QUALITY

2.13.1 Power Factor Correction

All electrical installations shall be designed with high efficiency equipment. All loads and equipment shall be provided with power factor corrective devices, to optimise the total connected load with high lagging power factor.

Power factor correction shall be considered for loads (buildings or individual switchboards, as appropriate) with a maximum demand of 400 A and above.

At the point of attachment to new buildings, the power factor shall be maintained at not less than 0.95 between 8:00am and 10:00pm weekdays at normal running load.

Units shall be reliable with a minimum life expectancy of 10 years for all components.

Power factor correction units shall be fitted with fault and overheating alarms that are integrated into the building alarm monitoring BMCS system.

Power factor optimisation equipment shall be in conjunction and coordinated with harmonic distortion minimisation devices.

2.13.2 Harmonics

Harmonic voltages and currents are undesired phenomena that occur in power systems containing non-linear electrical loads and are very common in contemporary electrical installations. The presence of harmonics in a system often results in increased heating in the equipment and conductors, misfiring in variable speed drives and torque pulsations in motors.

Where any non-linear electrical equipment is selected for installation, provision shall be made for additional harmonic mitigation/ filtration equipment. Such mitigation measures shall comprise active or passive equipment as appropriate to the interference issues that are present.

Harmonic filtration shall be provided to limit harmonic distortion at the point of common coupling (PCC). The definition of PCC shall be taken to mean, broadly, the point of connection of a specific load or

switchboard to other parts of the electrical installation – this may comprise the building HV connection point, building main switchboard, mechanical services or other plant switchboards or other distribution switchboards with harmonic rich equipment connected.

The maximum harmonic content at any of the selected PCC shall be maintained within the limits permitted for connection to the Western Power network. The equipment shall be placed within the electrical system in such a way to best protect the rest of the installation from the areas where harmonics are generated.

2.13.3 Lightning Protection

Lightning protection risk assessments shall be carried out on all UWA facilities to comply with *AS/NZS 1768*.

Risk assessment outcomes and mitigation strategies shall be agreed and recorded. Risks shall be mitigated, including provision of passive Faraday cage building protection. Active (collector) type building protection systems are not considered acceptable. As a minimum surge protection shall be provided on incoming and electrical distribution services.

2.13.4 Surge Protection

Provide surge protection devices in all switchboards in accordance with the measures as selected in the *AS/NZS 1768* assessment process. As a minimum, coarse protection shall be provided at every building entry and at all locations where the supply cabling is subject to elevated induced voltage through a lightning strike.

Surge protection equipment shall be installed with neon indicators visible through the switchboard escutcheon. The indicators shall display the condition of the suppression equipment and be connected to the BMCS.

2.14 LOW VOLTAGE WIRING SYSTEMS

Wiring systems throughout the campus shall primarily be run within hidden accessible spaces so as to allow for future removal, modification or maintenance. Wiring shall be concealed from view but installed in such a way so that it can be re-wired easily and without damage to finished surfaces and facades.

All wiring systems must comply with the latest requirements of *AS/NZS 3000* and *AS/NZS 3008*.

Cable shall be insulated with 0.6/1 kV grade PVC compound type V75 or higher. Cabling selection shall also be cognisant of the ESD requirements for the project.

Cable joints shall be avoided.

All wiring shall be adequately fixed and supported, installed with adequate air circulation and fixed to

permanent structural components of the building. Where cables supply emergency or safety circuits they shall be provided with protection against fire and mechanical damage.

Typically the following wiring systems may be used:

Location	Wiring System
Within concrete Slab	Unsheathed cable in heavy duty PVC conduit
Accessible Spaces	Insulated and sheathed cables on cable tray or basket tray.
Concealed Spaces	Unsheathed cable in PVC conduit
Plant Rooms	Cable protected in steel or PVC conduit or on cable tray
Rendered brick walls	Cable in PVC conduit
Stud Walls	Thermoplastic insulated and sheathed cables

2.14.1 Submains

All single core submains cables installed on cable ladders/trays/baskets shall be installed in trefoil arrangement.

Due care shall be taken to design cable routes within corridors, thoroughfares and vertical cable risers. Final routes shall be co-ordinated with other services and enable access along the full length for installation of future cabling in spare capacity space.

2.14.2 Final Subcircuit Cabling

Final Subcircuit cabling shall be coloured white and a minimum of:

- 2.5mm2 for Lighting Circuits (20 Amp circuit)
- 4mm2 for Power Circuits (20 Amp circuit)

As a general rule a maximum of five double 10A socket outlets shall be connected to one circuit.

All new power circuits shall have reserve capacity due to possible changes in power requirements in the building.

Multiphase switched socket outlets shall be on a dedicated circuit with an isolator.

Direct connected equipment shall be on a dedicated circuit with an isolator.

Communications/ IT equipment and critical equipment shall be on a dedicated circuit.

All fixed appliances such as electric stoves, hot water systems etc. shall be installed with a dedicated isolating switch mounted adjacent to the unit.

Soft Wiring Systems

Refer to Section 6.

2.14.3 Load Distribution

Single phase final subcircuits shall be divided across the three supply phases equally to achieve a load variation less than 10%.

2.14.4 Fire Rated Cable Systems

Cabling systems (comprising cable and supports) supplying Essential services as described in previous sections shall be rated as a minimum to WS52W classification in accordance with *AS/NZS 3013*.

The cable support system must be appropriately fire rated by the use of proprietary supports and fixings that meet the requirements of *AS/NZS 3013*.

Vertical cable runs shall be tied with stainless steel ties at no less than 600mm intervals.

2.14.5 Terminations

Copper Conductor Terminations

Lugs shall be compression type, sized for the conductor and compressed only by the correct tool.

Flexible Cable Terminations

The correct type of lug shall be used to ensure adequate clamping of fine multi-stranded cables.

2.14.6 Cable Support and Containment Systems

Cables shall be supported at all positions along the cable route to deliver a neat, practical and maintainable installation.

Cable support systems may comprise:

- Cable Tray
- Cable Ladder
- Cable Basket
- Cable Duct/ trunking
- Clips, cable ties and cleats.
- Catenary Wire

Cable tray, basket and ladder shall be galvanised or stainless steel and be complete proprietary systems. Only the same manufacturer's standard fittings and joining plates shall be used.

Trays shall be generously sized so that cables are not entangled and it is practicable to remove redundant cables as any become disused.

2.14.7 Underground Services

Underground services guidelines applies to all cabling systems including HV, LV, ELV and any other project specific wiring services.

All activities involved with underground services shall be coordinated with other services and be in accordance with *UWA Design and Construction Standards – Civil Works*.

The location and depth of existing underground services in the vicinity shall be confirmed during the design phase of the project and verified on site prior to commencement of any earth works or trenching. On site testing shall be undertaken through the use of Ground Penetrating Radar (GPR), potholing and other non-intrusive methods.

Trenching

Where existing services lay in the proposed route of a trench, provision shall be made for trenching by hand to avoid possible damage. Existing services shall not be tampered with in any way unless instructed by Campus Management. Accidental damage to existing services shall be reported immediately.

Trenching shall be performed at agreed times to minimise disruption to normal personnel movement.

Safety barriers shall be erected to direct personnel commuting in the area away from the work area.

Conduits must be provided for all underground cables installed beneath paths or roads whether sealed or not. Conduits must extend 1m on both sides of the road or path.

Spare conduits shall be provided along all mains cable routes.

Cable Pits

Cable pits shall be provided in cable routes at regular intervals and changes of direction to facilitate the ease of cable pulling and maintenance activities. All cable pit locations shall be coordinated with Civil work, Landscaping and other services.

Conduit entries shall be drilled neatly to the size of the associated conduit. Any gaps around the conduit and entry hole shall be suitably sealed. Drainage holes shall be drilled in the bottom of the pit.

Trafficable lids shall be installed to pits where there is an increased likelihood of vehicle movement.

Pits shall be sized to suit the bending radius of largest cable being installed.

Cable pit lids shall be labelled as to the service within.

2.14.8 Conduits

Where conduits are required for cable reticulation, the installation method preferred is PVC insulated

cables installed in Class B heavy-duty PVC conduit.

PVC conduit shall be used in areas where corrosive gases may be present. Where PVC conduits are installed in service areas or accessible roof spaces they shall be neatly racked and fixed to walls or structural members. They shall not be installed without further protection in areas where they can be damaged by traffic. Conduits shall be installed such that they do not obstruct access to roof or similar spaces.

PVC conduit must not be used where exposed to excessive temperatures, exposed to direct sunlight (e.g. in glasshouses) or where radio shielding of the power cables is necessary (e.g. Physics building). Heavy-gauge galvanised screwed steel conduit can be used as an alternative for these areas.

Conduits shall have a minimum diameter of 20mm. The number of cables installed in conduits shall comply with *AS/NZS 3000*.

Draw wires shall be installed in all conduits.

Heavy duty orange conduit and fittings shall be used underground and where exposed in plant and switch rooms, service ducts and roof spaces.

Exposed conduits are to be avoided wherever possible.

2.15 SEISMIC RESTRAINTS

All electrical plant and equipment, including the following parts and components and their connections shall be designed with seismic restraints for both horizontal and vertical forces:

- Substation components including transformers and HV switchgear
- Diesel generators
- Electrical switchboards and distribution boards
- Support frames for electrical equipment
- Uninterruptible power supplies (including batteries)
- Communication racks and cabinets
- Lighting fixtures
- Electrical and communications cable trays including supports
- All electrical conduits greater than 64mm internal diameter
- Bus duct

2.16 EARTHING

All buildings utilise a Multiple Earth Neutral (MEN) System. The MEN connection shall only be at the main switchboard and installed in such a fashion that it may be easily removed for testing purposes.

The MEN link shall be clearly labelled inside the main switchboard and on the outside escutcheon cover.

Earthing electrodes shall be selected as appropriate for the ground conditions and position of installation.

The main earthing cable shall be clamped to the earth electrode, sufficiently below finished ground level as to remain undisturbed, covered with a suitable earth pit labelled "MAIN EARTH" and "Warning Main Electrical Earthing Conductor Do Not Remove"

All metallic pipes, cable containment systems and exposed metalware within reach from electrical equipment, in the building, shall be bonded to the electrical earth.

2.17 LIGHTING

2.17.1 General

Lighting designs must meet all the applicable requirements of the *NCC*, *AS/NZS 1680, AS/NZS 1158* and other standards as relevant to specific building functions. All lighting designs shall provide adequate functional lighting to suit the tasks of the spaces, create a comfortable working space, complement architectural design requirements, be in accordance with sustainability requirements for the project, be simple to operate, be readily maintainable and flexible for future uses of the facility.

Areas shall be illuminated by natural light or artificial means to afford safety and visibility commensurate with the purposes of each area.

Where working positions are fixed, task lighting may be used.

Consideration shall be made for occupant safety and security lighting, including adequate provisions for night time.

Over lighting significantly above the Australian Standards (>25%) should be avoided.

Light fittings and components shall be assessed against the following points for selection:

- Energy Efficiency
- Maintainability
- Number of compatible lamps
- Switching control method
- Cost (capital and whole-of-life)

The type and position of fitting selected shall allow for easy repair and maintenance.

Recessed fittings shall be installed complete with a length of flexible cable and plug top.

2.17.2 Types of Lighting

Lighting designs shall deliver a complete lighting solution that is functional to the space and embraces the following elements:

General Environment Light

Environment light is the type of light that provides a blanket wash of illumination. The function of environment light is to facilitate general orientation and activity. Environment light shall be the base foundation allowing for additional accent lighting.

Task/Direct Light

Direct lighting can be used to provide contrast. This type of lighting shall be employed where the aim is to accentuate focal points and highlight important areas. An example where task lighting may be applied is within a laboratory.

Feature Light

Feature lighting (e.g., the use of coloured lamps and RGB LED fittings) may be used to create a decorative feature to the overall lighting design. Although feature lighting does not necessarily provide practical functionality, it shall be considered for public areas and foyers. This aspect of lighting could also assist with signage and wayfinding.

2.17.3 Luminaires

Luminaires installed within reach shall be suitably constructed or protected by guards against accidental damage so that bare lamps are not directly exposed.

Luminaires in plant rooms shall be suitably protected from physical damage.

Selected luminaires shall be of high quality construction fabricated by reputable manufacturers, with a long-term prospect of availability of spare parts and replacements for future maintenance and refurbishments.

All lighting designs shall incorporate contemporary lamp and luminaire selections that are proven through past installations and offering the latest in commercially available technology.

Light output from all luminaires shall be flicker-free.

LED fittings shall primarily be considered for new or refurbishment projects. Feasible alternatives may be considered through consultation with UWA. Only energy efficient alternatives will be considered.

LED fittings must be manufactured by a reputable manufacturer with representation and support in Perth. All luminaires shall comprise matched lamps and drivers and have proven photometric performance, colour stability through life, demonstrable lumen depreciation, guaranteed lumen output for the nominated life of the fixture and guarantee of replacement parts. All luminaires shall be provided with an unconditional warranty for the life of the fixture.

2.17.4 Lamps

The performance of any luminaire depends on the light source (lamp) used.

All lamps throughout shall be of the same make and type and provide energy saving characteristics. All filament type lamps shall be avoided.

Colour temperature of lamps shall be determined in the design phase to best suit the room functionality.

Fluorescent tubes may be used in refurbishment projects when required for consistency with existing building portions. Such lamps shall generally be white 16mm diameter T5 4000K with a colour rendering index of >Ra84 and provided with a 'Long Life' guarantee by the manufacturer for a minimum of 13,000 hours.

2.17.5 Lighting Control

Energy consumption is to be minimised through the use of appropriate lighting control. Simple uncomplicated local control is preferred.

Lighting control functionality shall be determined during design phase and shall best suit the intended purpose of the room and take into account requirements of NCC and Sustainability initiatives. Where automatic control of lighting is used, a prominently mounted separate manual switch shall be provided in the area serviced to directly override all automatic controls.

DALI control systems shall be considered primarily for major refurbishments, new buildings or where existing DALI infrastructure is installed.

Lighting control is generally achieved via motion sensors, although must not be used when it poses a safety risk. Controller override switches shall be installed to allow lighting to work in the event that a controller fails.

General light switches shall be positioned in easily accessible locations for operation by staff.

Lighting in lecture theatres shall dim to 20% after 30mins without motion detection. After a further 5mins, the lights should turn off.

Lighting within multipurpose rooms such as meeting rooms and teaching facilities shall be controlled via motion sensors on a 15 minute timer.

2.17.6 Emergency Lighting

Emergency and Exit lighting shall be provided in all areas as per the requirements of *AS 2293* and *NCC*.

In addition, emergency lighting shall be provided in corridors, stairways, plant rooms, substations, switch rooms, comms/ IT rooms and other areas as required for the safe management of user care.

Emergency lighting shall be connected to a central monitoring system to enable testing in accordance with *NCC* requirements. The central monitoring should be installed as an extension of the existing system where practical.

2.17.7 Exterior Lighting

External areas shall be provided with lighting for the purposes of safety for pedestrian movement and egress from the building, identification of traffic ways, identification of features and architectural design elements (this may also be coordinated with artwork, signage and way finding), enhancement of night-time visual effects (including consideration of landscaping elements) and avoidance of insecure dark spaces.

External lighting may be fixed to the building or mounted on separate columns. The type of external lighting selected is to harmonize with the building décor, coordinate with CCTV and conform to the general landscape in the area.

External lighting shall be connected to circuits separate from those supplying the lighting in foyers, entry porches, emergency escape passageways and similar areas providing means of entry or egress. External lighting circuits are to be controlled by the BMCS. All circuits shall include a manual override switch to enable daytime maintenance.

The primary preferred lamp source shall be LED. External lighting columns shall be selected to coordinate with external landscape and architectural design.

All external lights/ poles are to be uniquely numbered. Numbers will be allocated to a scheme approved by Campus Management and are to be marked on the fitting or its support by stenciling in 25mm high letters.

2.18 POWER OUTLETS

2.18.1 Distribution of Power Outlets

Power outlets shall be distributed to provide a fully functional space.

The quantity, capacity and position of outlets shall be determined to suit the purpose and user requirements of the space. All spaces shall have access to power for maintenance purposes without needing to run cords through a doorway.

All Switched Socket Outlet (SSO) provisions shall be coordinated with data and other communications outlets appropriate to equipment to be installed in the space.

Power outlets for workstations shall be designed to suit the user's requirements, including outlets above and below the desktop. Consideration of installation of USB charging outlets shall be made to avoid the need to plug in portable charging power packs.

Where flexibility of power outlet use is considered necessary (for example, laboratories and workshops), such outlets shall be installed on wall mounted trunking with capacity for installation of future outlets.

2.18.2 Emergency Stop Isolators

Devices that cannot be shut down in the usual manner during emergency situations shall be fitted with emergency stop isolators. Coordinate emergency stop isolators with other services, such as gas isolation valves.

Laboratories and similar tutorial spaces shall be assessed for the requirement of its own local switchboard and emergency stop isolators.

Emergency stop isolators shall be twist and release type and not key operated.

2.18.3 Hand Dryers

Electric hand dryers shall be installed in high-use toilets and all accessible toilets. Refer *UWA Design and Construction Standards – Building and Architecture* for more information on hand dryers.

2.18.4 Clock System

All clock systems shall be Ingrams GPS System on either battery or mains power.

2.19 LABELLING

All labelling shall be provided and reflected in as-constructed documentation for ease of ongoing operation and maintenance. All numbering sequences shall coordinate with UWA labelling requirements, building identification and system-wide procedures across all services. All numbering shall be devised with adequate flexibility to accommodate additions and alterations that may occur to the building throughout its life.

Any labelling across the electrical distribution system that impact on other services shall be coordinated with all other disciplines.

2.19.1 Switchboards and Distribution Boards

All components on switchboards shall be clearly labeled with engraved traffolyte labels fixed by means of stainless steel bolts complete with washers, spring washers and nuts. The use of adhesive labels is not permitted.

Labeling shall display the building number, building name, switch board number and where it is fed from. Main labels shall have 25mm high lettering.

Numbers on any one floor run consecutively from one distribution board to another, although blocks of reserved numbers may be allocated to each distribution board.

2.19.2 Light Switches and Power Outlets

The standard method of marking is of IPA stud markers for circuit identification. IPA studs shall be provided for all accessories. All accessories connected to alternative power source (such as UPS, Essential supply, alternative/ redundant supply, etc.) shall be colour-coded and appropriately labeled for ease of identification.

New power outlets may be labeled with adhesive engraved type labels fitted to the face of the outlet as well as the IPA stud. The IPA stud shall be fitted to the accessory in such a way that it will not be removed when removing the faceplate or cover.

Engraved labels shall detail the DB number from which it is fed as well as the circuit identification number, e.g., DB G.1 R7.

This labeling method applies to all light switches, power outlets and isolating switches of fixed electrical equipment.

Lighting control devices and switches connected to an ELV control system (such as C-bus, DALI, etc.) shall be clearly identified with unique code, bar code or other readily identifiable code to facilitate ease of maintenance.

2.20 VARIABLE SPEED DRIVES

Variable Speed Drives may be used for control of mechanical equipment such as pumps and air handling units. VDSs shall be of high quality and reputable manufacturer.

VSDs shall be appropriately sized for the application or equipment of which it is serving. Installation shall be in line with manufacturer's requirements. Refer to *UWA Design and Construction Standards – Mechanical Services.*

Variable speed drives (VSDs) shall be supplied with harmonic and RFI filtering equipment to meet power quality requirements.

2.21 BMCS INTEGRATION

The Building Management and Control System (BMCS) is generally provided as part of Mechanical Services or Communications Services works. All portions of the electrical installation that require monitoring by an electronic control system for operation, management and/or maintenance shall be connected to the BMCS.

In general, it is intended that the BMCS be provided with comprehensive information regarding the operation of all plant and equipment within the building. All proprietary control systems of electrical equipment shall be provided with Status and Alarm identification to the BMCS.

The following equipment should be connected to the BMCS:

- HV switchgear, power supplies

- LV main switches and transfer/ load shedding control systems
- Surge Protection Equipment
- Generator and Back-up Power Systems, including fuel systems
- UPS systems, battery systems
- Power Factor Correction and Harmonic Filtration Units
- Lighting control system
- Emergency lighting systems
- Street and other External Lighting

2.22 ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

Areas and rooms may contain elements such as flammable gas, combustible dust and flammable liquid that produce vapours. These areas may be classified as hazardous due to the atmosphere potentially becoming explosive.

Hazardous Area Classification Specialists should be engaged for classification of areas.

Electrical equipment that must be installed in such classified locations shall be specially designed and tested to ensure it does not initiate an explosion due to arcing contacts or high surface temperature of equipment.

The following situations may give rise to a hazardous area:

- Heavier than air bottled gas cylinders with an aggregate gas capacity exceeding 30m3 (e.g., liquid petroleum gas (LPG))
- Gas-tank filling or discharge connections
- Pressure relief device discharge points fitted to gas installations

Areas that may be classified as being Hazardous are:

- Laboratories
- Chemical Stores
- Gas Stores

Electrical equipment shall be installed in accordance with relevant *AS/NZS 60079* parts as appropriate to the area.

2.23 REDUNDANT CABLING AND EQUIPMENT

All redundant cabling and electrical equipment removed during demolition or modifications to existing systems shall be returned to UWA in the condition of which it was removed.

Cabling shall be removed wherever possible, however, where cabling cannot be completely removed, the cable ends shall be confirmed and made safe by means of junction boxes, termination connectors and information tags.

2.24 SAFETY IN DESIGN

Incorporate design solutions that minimises the potential for danger during construction as well as during occupation and maintenance.

Regular reviews shall be undertaken progressively through the various stages of design to facilitate optimal solutions to minimise unsafe risk issues. The opportunity for UWA staff to be involved in such workshops and reviews shall be provided.

2.25 TESTING, COMMISSIONING AND CERTIFICATION

Prior to practical completion, testing and commissioning shall be performed on all installed equipment and systems to verify that they operate correctly and function as intended.

Testing and commissioning shall include:

- Inspection of each element to establish it is complete and of the quality required for the function/ use of the space
- Testing of each element and service to establish it performs correctly in each operating mode, including operating sequences and interlocks
- Review of arrangements for operation, servicing and maintenance to ensure that they are adequate for UWA needs
- Thermographic survey of switchboards, switchgear and cable joints
- Calibration of controls and protection
- Checking the certification provided by the supplier of electrical switchgear that circuit protection discrimination complies with requirements.

Additional commissioning and certification shall be delivered to demonstrate compliance of:

- HV switchboards and transformers
- LV switchboards
- Essential power supply sources
- The low voltage installation
- Emergency lighting installation
- Lightning protection systems.

Results should be incorporated into the As Installed documentation and handed over as part of Practical Completion

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2.25.1 Inspections

The University reserves the right to carry out inspections during the course of construction and to undertake tests on completed installations.

Witness testing may be required for various testing and commissioning activities.

2.26 AS INSTALLED DOCUMENTATION AND OPERATIONS AND MAINTENANCE MANUALS

All projects shall be completed with the handover of As Built documentation detailing all information necessary to enable safe and efficient ongoing operation and maintenance of the new works. In some cases, this documentation may need to take the form of upgrading existing documents. All such As Built documentation shall include the following information as a minimum:

- Maximum Demand and cable sizing calculations and/ or measurements
- Power and lighting layout diagrams, including all circuiting and controls details
- Dimensioned positioning of all in-ground and concealed services
- Electrical schematic diagrams
- Switchboard and single line diagrams
- Earthing positions and tested earth resistance measurement
- Technical catalogue and documents for all installed equipment
- Schedules of all points lists and control ladder diagrams
- Lighting control points list and schedules
- Compliance certificates
- Samples of all proposed electrical equipment
- Operation instructions
- Contact details and schedule for all spare and replacement parts
- Maintenance manuals, testing registers and schedules

Refer *UWA Specifications for As-Constructed Documentation* for further information.

2.27 ASSET REGISTER

The addition and removal of the following list of assets shall be updated on the UWA asset register.

- HV switchgear and Ring main units
- HV Cables
- Transformers
- Switchboards
- Generators
- Uninterruptible power supplies
- Power factor correction and harmonic mitigation units
- Battery banks
- LV air circuit breakers

- Residual current devices
- Emergency and Exit Lighting

The following details shall be entered into the asset register:

Switchboards

- Manufacturer
- Main switch size
- Switchgear make
- Number of ways, RCDs and spare ways.
- Supply source and rating

Generators / PFC / UPS / Battery Banks/ AHF

- Manufacturer
- Make/model
- Serial number
- Rating

HV Switchgear/ Ring Main Units / Transformers

- Manufacturer
- Make/model
- Serial number
- Rating
- No. of ways (HV switchgear)
- Supply source and rating

HV Cables

- Size/ type
- Length
- Rating

3 Checklist for Project Team

The following activities should be considered by the project team during the planning of the project.

Activity			
Assessment of load profile	Electrical consultant	CM (Engineering Services / Client Faculty)	Gate 2 Feasibility
Capacity of existing infrastructure to cater for new loads	Electrical consultant	CM (Engineering Services)	Gate 2 Feasibility
Allocation of Essential services including design for Redundancy and Criticality	Electrical consultant	CM (Engineering Services)	Gate 2 Feasibility
ESD Considerations (solar option, efficiency of motors and equipment, lighting type and controls, VSDs, metering, etc.)	Electrical consultant	CM (Engineering Services)	Gate 2 Feasibility
Design for Maintainability and Access	Electrical consultant	CM (Engineering Services / Building Operations)	Gate 2 Feasibility
Design for Essential services including back-up supply (HV / LV interconnection, UPS, generators, etc.)	Electrical consultant	CM (Engineering Services)	Gate 3 Planning
Allowance for Spare Capacity	Electrical consultant	CM (Engineering Services)	Gate 3 Planning
Provision of Revata to all meters, monitoring/ alarms, etc.	Electrical consultant	CM (Building Operations)	Gate 3 Planning
Allowance for painting and labelling to UWA standards	Contractor	CM (Engineering Services)	Gate 3 Planning
Design for Safety (isolators, remote monitoring, etc.)	Electrical consultant	CM (Engineering Services)	Gate 3 Planning
Electrical provisions for other services (e.g., fire pumps, hydraulic valves, BMCS controllers, fume cupboards, plant rooms, etc.)	Electrical consultant / Contractor	CM (Engineering Services / Building Operations)	Gate 3 Planning
Allowance for factory testing / on-site testing	Electrical consultant / Contractor	CM (Engineering Services / Building Operations)	Gate 5 Construction

4 Specifications

4.1 PREFERRED SUPPLIER LIST

Item	Preferred Suppliers
HV Network Feeder Cable	• Nexans Olex • Prysmian • Western Power – Equipment Stores
HV Transformer Cable	• Nexans Olex • Prysmian
HV Switchgear	• Schneider • ABB • Eaton • GE
HV Power Transformers	• ABB • Schneider • Wilson
kWH (Tariff) Meters	• Schneider
Switchboards	Commercially available products to UWA approval
Distribution Switchboard Chassis	• Schneider ISO Bar
Cable Ladder & Tray	Commercially available products to UWA approval
LV Cable	Commercially available products to UWA approval
LV Electrical Components (Switches, SSO's etc)	• Clipsal 2000 Series
Lighting Control System	• Dynalite • Organic Response
Emergency Light Monitoring System	• Stanlite Nexus RF
Hand Dryers	• Dyson

5 Requirements for Networked Electricity Meter Selection and Installation at UWA

5.1 INTRODUCTION

The purpose of section 5 of the document is to describe the acceptable standards, products, installation, connection and commissioning requirements for electrical metering equipment provided to the University of Western Australia Campus.

Selection and installation of metering equipment for the Campus shall comply with Australian and International Standards and the requirements described in this document.

Where meters are utilised for custody transfer, billing purposes or any other purposes of trade, only meters with current Pattern Approval Certification from the National Measurement Institute of Australia shall be selected.

Criteria for meter selection include:

- Compliance to applicable Standards.
- Accuracy class.
- Networking and communications capability.
- Availability of product and technical support within Australia.
- If for purposes of trade, Pattern Approval Certification from the National Measurement Institute of Australia.

Criteria for meter installation include:

- Compliance with applicable Standards, Codes and Legislation.
- Consistent installation methodology.
- Correct and consistent commissioning and verification procedures.
- Accurate and consistent documentation and record keeping.

All installation work shall be carried out only by electrical workers suitably licenced to work on the metering equipment with consideration to the electrical voltages present.

5.2 ELECTRICITY METERS AND ASSOCIATED EQUIPMENT

Meter network communications may be either Ethernet or EIA-485 based depending on the meter location and the availability of UWA Ethernet data points or switch ports at the meter's location.

As a general rule:

- If one meter is to be installed at a meter location then that meter may be Ethernet based and connect directly to the UWA Ethernet.
- If multiple meters are to be installed at a location then those meters shall be EIA-485 based

and shall utilise an IP Network Gateway (Ethernet gateway) to connect to the UWA Ethernet.

5.2.1 Electricity Meters – For Monitoring Purposes (Analysis)

Meters utilised for monitoring purposes shall:

- Comply with AS62053-21 (formerly IEC 62053-21) Class 1.0 for real energy measurement.
- Include Modbus serial (EIA-485) or Modbus/TCP communications capability.
- Include a local (faceplate) LCD display for the viewing of parameters and for validation purposes.

5.2.1.1 Acceptable meters include:

- Schneider Power Logic PM5310 series.
- Satec EM133 TOU Smart Meter series.

5.2.2 Electricity Meters – For Billing Purposes (Purposes of Trade)

Meters utilised for the purposes of trade must:

- Be pattern approved by the National Measurement Institute of Australia (NMI). Meters subject to or under grandfathering or transitional arrangements by the NMI shall not be accepted.
- Be verified in accordance with the National Test Instrument Procedures (NITP 14 Utility Meters).
- Include a “non-resettable” counter.
- As a minimum, comply with AS62053 (formerly IEC 62053-21) Class 1.0 for real energy measurement.
- Include Modbus serial (EIA-485) or Modbus/TCP communications capability.
- Include a local (faceplate) LCD display for the viewing of meter parameters and for validation purposes.

5.2.2.1 Acceptable meters for the purposes of trade include:

- Schneider Power Logic iEM3255 series.
- Schneider Easy Logic EM1350 series.
- Satec EM133 TOU Smart Meter series.

5.2.3 Ethernet Gateways

Ethernet gateways shall be used to connect EIA-485 networked electricity meters to the existing UWA Ethernet network that supports the iEnergy meter reading system. Acceptable Ethernet gateways include:

- Schneider EGX Link 150 series.
- Moxa MGate series.

A maximum of twenty meters may be connected to any one Ethernet gateway.

5.2.4 Alternative Products

As manufacturers modify their product and model offerings from time to time alternative products may be proposed in lieu of those designated however they must be equivalent or superior to the meters and gateways listed in sections 2.1, 2.2 and 2.3 Details of proposed devices detailing all relevant technical and compliance parameters must be submitted to UWA Campus Management for approval before being utilised on the site. UWA is not obliged to accept any proposed alternative.

5.2.5 Ancillary Equipment

Meters shall be provided with all ancillary equipment necessary for mounting and connection to the monitored circuits or equipment. Ancillary equipment includes:

- Current Transformers where meters are not directly connected.
- Voltage Transformers where voltages exceed the meters operating voltages.
- Fuses and Protective Devices.
- Test Links.
- Terminal and Shorting Blocks.
- Cabling.
- Conduit and Ductwork.

Current and voltage transformers must be compliant with the requirements of AS60044 and shall be of a sufficient accuracy so as to ensure that the associated meters meet the accuracy class specified.

Shorting and test links shall be installed for all current transformers.

Voltage (potential) transformers shall be installed for high-voltage metering applications and are to incorporate fusible link protection on the secondary side.

Fusible links shall be installed for all voltage (potential) connections to meters.

Current and voltage transformers must be installed so that the manufacturer's ID label and the rating of the transformer is directly visible without the use of mirrors or the like.

Wherever possible voltage transformer potential fuses and current transformer links shall be fitted within the switchboard or meter enclosure. If this is not practicable, then the location of the fuses and links shall be clearly identified on a label permanently affixed at the meter location.

5.3 COORDINATION

Prior to the commissioning of any new networked meters the meter contactor must liaise with UWA Campus Management in order to coordinate the meter commissioning date and time.

UWA Campus Management:

Email: buildingops-cm@uwa.edu.com

UWA Campus Management will coordinate the iEnergy provider to undertake all configuration modifications to the iEnergy software as necessary to include for the integration of new meters.

The contractor shall liaise with UWA CM during the commissioning and verification process to confirm that meters are communicating with, and passing data correctly to the iEnergy meter monitoring system.

5.4 INSTALLATION REQUIREMENTS

Electricity is supplied to and reticulated around the site via high voltage (HV) ring mains. The HV supply is stepped down to low voltage (LV) via transformers in substations local to the end user.

Meters on three phase supplies must be installed as 3 phase – 4 wire (includes a neutral connection) connections with separate current transformers and voltage tappings on each phase.

Wherever practicable, meter sensing devices such as current and voltage transformers shall be installed on the load side rather than the line side of main isolation switches.

Meter installations must include suitable protection for the meters and ancillary equipment sized and ranged to suit fault voltages and currents.

Meter protection and isolation devices such as potential fuses and shorting / test links shall wherever possible and practical, be installed in separably accessible sections of switchboards.

Meters must be installed so that they can be readily accessed for viewing and maintenance without the need for ladders or the like. Meter faceplates shall be accessible for viewing, configuration, validation and meter parameter display purposes.

5.4.1 New Installations – Low Voltage

For new low voltage installations, meters shall be installed as integral components within a separate metering section of the electrical LV switchboards. The meter and associated ancillaries such as current transformers and voltage connections must be installed so as to ensure that all power distributed by the LV switchboard is metered. There must be no unmetered power leaving the switchboard.

5.4.2 New Installations – High Voltage

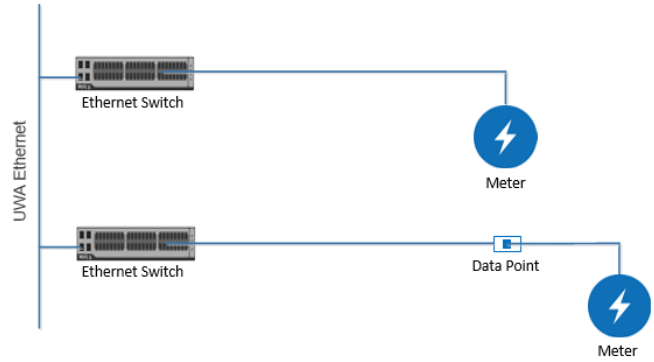
For all new high voltage installations, metering installation requirements shall be confirmed with UWA Campus Management.

5.4.3 Network Cabling

5.4.3.1 Ethernet Meter Network Cabling

All Ethernet meter network cabling (fixed and patch) shall be as per the meter manufacturer's specification. If not specified, Category6A cable shall be utilised.

Simplified sample acceptable Ethernet meter connection topologies are represented in the following figure:



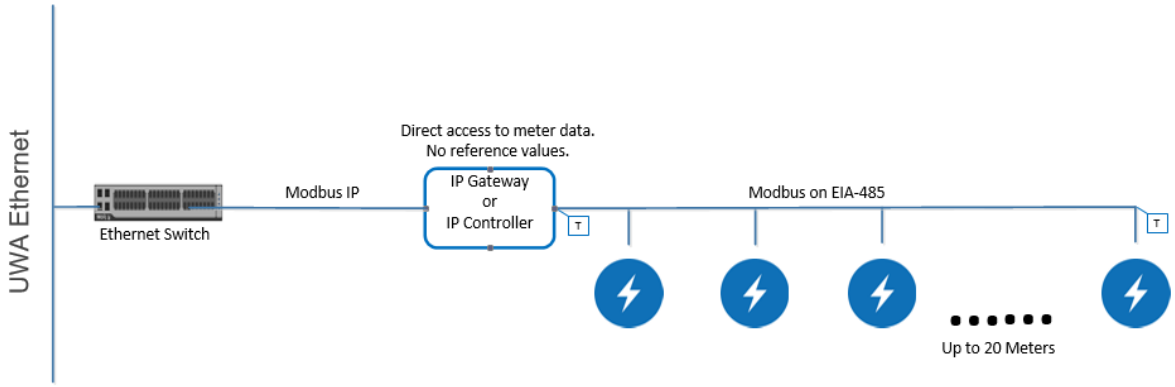
5.4.3.2 EIA-485 Meter Network Cabling

All EIA-485 meter communications cabling shall be as per the meter manufacturer's specification. If not specified, Belden 9841 cable shall be utilised.

EIA-485 meter communications cabling shall be installed and terminated in a Bus topology. Line resistance shall be compliant with the meter manufacturer's recommendation. Supply and install any end-of-line resistors required to maintain correct line resistance.

Where EIA-485 meter communications cabling spans between buildings, surge protection must be provided at each end where the cabling leaves and enters buildings. Surge protection devices shall include on-board visual indicators of operation and actuation.

A simplified sample acceptable EIA-485 meter connection topology is represented in the following figure:



5.4.3.2.1 Referenced Data (values) and EIA-485 connected meters

Where meters are connected via EIA-485 networks, all meter data must be directly accessible and readable by UWA Ethernet users and iEnergy. Meter data shall not be hidden, mirrored or otherwise represented by proxy in reference points residing in IP controllers utilised as Ethernet gateways. Meter data resident in, and accessible only from IP controller reference points will not be accepted.

5.4.3.3 Segregation

All meter communications cabling installed within electrical switchboards, switchrooms and shared cable containment shall be installed in compliance with AS/ACIF S009:2001 and ACMA Customer Wiring Rules and Requirements. Mandated segregation distances between communications and power cables must be maintained. All meter ELV and communications cabling within electrical switchboards shall be installed within conduit or duct.

5.4.3.4 Surge Protection

Where EIA-485 meter communications cabling spans between buildings, surge protection must be provided at each end where the cabling leaves and enters buildings. Surge protection devices shall include on-board visual indicators of operation and actuation.

5.4.4 Labelling

UWA's meter tag schema shall be adhered to for all new meters. Meter tag IDs shall be provided by UWA Campus Management.

Meter labels shall be included for each meter and shall be self-adhesive traffolyte fixed with non-conductive screws or barbed pins and shall be located immediately above or below the meter. Lettering shall be black on white and be 5mm high.

Meter labels shall include the following information:

- The Site Number.
- The Building Number.
- Meter Tag.

- Barcode Asset Tag.
- Metered Service.
- Meter CT ratio.
- Origin of Supply.

Where meter potential fuses and/or CT links are not located immediately adjacent to the meter, the location of those fuses and links must also be included in the meter label.

5.4.5 Meter Security

Password protection shall be implemented at the programming/configuration level for each meter. Default passwords shall be initially set to “0000”. Operational passwords shall be provided by UWA Campus Management.

Meters used for purposes of trade shall be mechanically sealed, meter seals shall only be removable via the use of a tool.

5.4.6 Ethernet Gateways

Wherever practicable Ethernet gateways shall be installed adjacent to the nearest Ethernet network switches that support the iEnergy meter monitoring system. If Ethernet gateways must be installed in switchrooms or otherwise adjacent to meter locations, enclosures shall be provided for those gateways. Gateway enclosures shall include the gateway power supplies and all ancillary equipment necessary such as isolator switches and circuit-breakers. Gateway enclosures shall otherwise meet the requirements of UWA Design and Construction Standards – Electrical Services.

The contractor shall provide and install Ethernet fixed or patch cables between gateways and available RJ45 ports on the Ethernet switches and shall be responsible for:

- Configuration of IP Addresses into the gateways.
- Configuration of the EIA-485 communications parameters into the gateways.
- Configuration of the meter node address availability range into the gateways.

As Ethernet gateways consume Ethernet network resources, meter connection networks should be designed, configured and installed in such a way as to minimise the number of gateways required.

5.5 COMMISSIONING AND VERIFICATION

Commissioning, verification and documentation shall be undertaken for each new networked electricity meter by a suitably qualified meter technician.

5.5.1 Meter Commissioning

Meter commissioning shall confirm that the meter is functional across its measured range and that the meter is:

- Installed to the correct location (by matching the meter serial number to the designated

location).

- Correctly wired to meter sensing and protection devices such as:
    i. Current transformers and voltage connections and/or transformers
    ii. Potential fuses.
- Correctly configured for sensor device ratios (e.g. CT and VT Ratios).
- Configured with the correct wiring configuration (e.g. 4 wire WYE).
- Configured to make available all measured parameters and maximum demand values and times from the internal Modbus registers of the meter.
- Configured to display measured values on the meter faceplate.
- Configured to display site, building and meter details on the scrolling LCD display (where applicable).
- Configured to display set-up parameters on the meter faceplate (password protected).
- Configured to communicate to the iEnergy meter monitoring system via:
    i. An EIA-485 serial communication connection.
    ii. An Ethernet connection.

5.5.1.1 Meter Faceplate Display

Where meters have the capacity for a scrolling display on the LCD viewing screen, the following information shall be included in the sequential scrolling display:

- Site Number – (e.g.“900”).
- Building Number – (e.g. “B245”).
- Meter Location – (e.g. “CTec MDB1”).
- Metered User – (e.g. “Level 1 Tenant”).
- Metered Service - (e.g. “LV Essential Supply”).
- Meter Tag - (e.g. “UWA-T-CTec1A”).
- Current Date and Time.
- Total Consumption in kWh or MWh as applicable.
- Instantaneous Power Demand in kW or MW as applicable.
- Individual Phase Currents in Amps.
- Voltages Phase to Phase and Phase to Neutral.
- Current Transformer (CT) ratio.

5.5.1.2 Meter Commissioning Documentation

Meter commissioning documentation shall confirm that the commissioning process has been completed successfully and in its entirety and shall include the following as a minimum:

- A unique document per meter commissioned.
- Location, manufacture, model, tag and serial number of the meter commissioned.
- Size of the submains that the meter is measuring.
- Record of meter sensing device ratios (CTs and VTs).
- Confirmation of correct wiring between the meter and the meter sensing devices.
- Confirmation of correct orientation of CT's.
- Record of each configuration parameter programmed into the meter.
- Record of each measuring parameter programmed into the meter.
- Confirmation of serial communications from the meter to the IP Network Gateway and to the iEnergy meter monitoring system.
- Record of any faults identified and of any corrective action recommended or taken.
- Date and time of commissioning, business name, name and signature of meter technician.

Refer to Appendix A of this document for a sample power meter commissioning document.

5.5.2 Meter Verification

Meter verification shall confirm that the meter and its associated sensing equipment is accurate across its measured range of parameters and shall document any departures identified. The verification procedure shall confirm that each measured parameter of the meter is verified against a certified electrical testing reference instrument.

5.5.2.1 Meter Verification Documentation

Meter verification documentation shall confirm that the verification process has been completed successfully and in its entirety and shall include the following as a minimum:

- A unique document per meter verified.
- Reference instrument details including, manufacture, model, serial number and calibration information.
- Location, manufacture, model, serial number and tag of the meter verified.
- Record of the testing of each measuring parameter programmed into the meter against those of the reference instrument. Verified measuring parameters shall include as a minimum:
    i. kW
    ii. kVA
    iii. kVar
    iv. Power Factor
    v. Frequency

vi. Current per Phase

vii. Voltage (line to neutral)

viii. Voltage (phase to phase)

ix. Total Harmonic Distortion (THDi and THDv).

- Record of any faults identified and any corrective action recommended or undertaken.
- Date and time of verification, business name, name and signature of meter technician.

Refer to Appendix B of this document for a sample electrical meter verification document. Responsibilities and Demarcation

5.5.2.2 Meter Contractor

It shall be the responsibility of the meter contractor to select the correct meter type and sensing size, the range and capacity of associated meter ancillaries (e.g. current and voltage transformers) in order to ensure their suitability for purpose.

The contractor's meter technician shall be responsible for the installation, configuration, verification and commissioning of meters and Ethernet gateway devices and to confirm that meter data is accurate, and is being transmitted correctly to the iEnergy meter monitoring system.

The contractor shall be responsible for liaising with and applying for and acquiring Ethernet addressing information for IP meters and Ethernet gateways from UWA Campus Management including:

- VLan ID.
- IP Address.
- Sub-net mask.
- Default gateway
- Ethernet switch port assignment.

5.5.2.3 iEnergy Contractor and Meter Contractor

It shall be the responsibility of the iEnergy contractor to liaise and work with the meter contractor to initially commission and verify the meter readings into the iEnergy metering system and to then re-validate the readings a second time after nominal period of time and electrical consumption has transpired.

It shall be the responsibility of the meter contractor to liaise and work with the iEnergy contractor to initially commission and verify the meter readings into the iEnergy metering system and to then re-validate the readings a second time after a nominal period of time and electrical consumption has transpired.

5.5.2.4 UWA

It shall be the responsibility of UWA Campus Management to:

- Approve alternate products.
- Provide meter tag information.
- Provide meter barcode asset tag.
- Provide meter passwords.
- Provide VLan and IP Addressing information.
- Configure IP meters and gateways onto the UWA Ethernet.

6 Soft Wiring System

6.1 INTRODUCTION

6.1.2 Purpose

The purpose of this brief is to set out University's minimum requirements for the design of soft wiring system within items of loose furniture. The aim is to meet full compliance with relevant legislation and standards whilst retaining a degree of flexibility for the University in its operations.

Any design aspects not specifically addressed by this brief or variations to the design standards requirements shall be identified by the consultant during the design process and shall be brought to the University's attention for resolution. Variations in the design standard shall be submitted in writing to Director, Campus Management or nominated delegate for comment and approval, prior to any such changes or variations being implemented.

It is mandatory that the installation of electrical services and equipment comply with all current statutory requirements and current Australian Standards; hence these are not specifically referenced as part of this document.

In all instances the design shall be carried out in accordance with the latest edition of AS/NZS 3000 & AS/NZS 4703.

For the purpose of this design brief, whenever reference is made to University it shall be understood to mean the University Services Project Manager or University's nominated representative for the project. In all instances the soft wiring system services shall be documented in accordance with this design standard, in consultation with the designated University representative.

This document provides confirms the required method and standards to be adopted for all furniture fixed electrical services as defined under AS/NZS 4703.

6.1.3 Scope of Works

The scope of works for the electrical services is defined on a project by project basis in a separate consulting agreement document which is to be read in conjunction with this brief. Note that this brief generally covers works associated with electrical services only and does not generally cover the Soft Wiring aspects of a project.

For details on the communications systems requirements, refer to the University Data Communication Cabling Standards and Specification.

It should be noted that all CAT6/6A communication cabling should only be terminated to a fixed non-movable building fabric such as walls, floor boxes, columns or permanently fixed laboratory benches/furniture adjoining a wall. CAT6/6A cabling shall not be run through loose furniture. From the fixed wall point fly leads will be used to directly connect into the item of equipment.

6.1.4 Regulations

All designs shall be prepared to ensure compliance of the installation can be achieved in accordance with, but not limited to, the following standards;

- AS/NZS 3000
- AS/NZS 3008
- AS/NZS 4703
- AS/NZS 3105
- AS/NZS 3100
- Office of Energy (WAER)

It shall be noted that AS/NZS 4703 contains specific requirements not only relating to the quality of material, but also installation methods for electrical services within furniture.

6.2 SYSTEM COMPONENTS

6.2.1 General

The following system component requirements define the minimum standard acceptable to the University.

Where components are referred to using a brand name or reference this does not imply exclusivity for that item or brand, but does indicate required properties of quality, finish, method of construction, performance and similar that have previously been deemed acceptable to the University.

Variations in the design standard shall be submitted in writing to Director, Campus Management or nominated delegate for comment and approval, prior to any such changes or variations being implemented.

6.2.2 Starter Socket

A fixed connection point into the permanent electrical installation has traditionally been achieved using a proprietary manufactured starter socket. For University projects the starter socket shall be a 20A rated switched socket outlet equivalent to Clipsal 2015/20. The outlet surround shall be engraved in accordance with requirements for a socket outlet and labelled as “Soft Wiring Outlet”.
The use of a soft wiring manufacturer’s proprietary starter socket, which is brand specific, will not be permitted under any circumstance.
The use of auto disconnect socket outlets shall not be permitted.

6.2.3 Interconnecting Lead

All interconnecting leads within a soft wiring system shall be double insulated with a minimum 20A rating.

All leads and associated plug connectors shall be manufactured in accordance with AS/NZS 60898.1.

The designer shall ensure that strain relief of the lead is provided. This is of particular importance for the lead between the wall starter socket point and furniture.

Ensure that any lead within the furniture is correctly supported and not allowed to drape along the floor. Where not installed within a cable management system cables shall be secured at 300mm intervals as required by AS/NZS 4703.

Where multiple sections of furniture are interconnected using a soft wiring system each section of desk shall be fixed together, to ensure that leads are not unnecessarily strained if the furniture is pulled apart.
For height adjustable workstations the cable lead between the under desk cable tray and any above table top socket outlet shall be installed within a flexible umbilical to ensure that when lowered from the fully extended position the cable lays back into the cable tray.

6.2.4 Furniture Fixed Socket Outlets

All socket outlets shall be of the individually switched type. The use of auto switch socket outlets shall not be permitted.

Outlets shall not be mounted flat (facing up) under any circumstances, irrespective whether an overall cover is provided or not. All outlets shall be installed so as to maintain a min 30 degree incline from the horizontal.

Above desk socket outlets are typically provided as an angled clamp on unit. The height of the clamp on housing shall maintain a minimum clearance of 50mm between the bottom of the lowest pin on the outlet and the surface of the worktop. This is to ensure that a range of plug top chargers can be used. The table top outlets can also contain USB charging points; these should be limited to a maximum of two per module to avoid overheating. As an example CMS Electracom offer a range of table top outlets that achieves these minimum requirements.

The maximum number of soft wiring outlets connected to a wall mounted starter outlet shall be limited to:

Staff Workstation: Maximum of 4 workstations comprising of 3 double socket outlets (Total 12 double outlets).

Student Workstations: Maximum of 4 off single or can a combination of multiple outlets.
Below desk outlets are typically fixed to an under desk cable tray system or directly under the counter top. These outlets shall be provided with a mounting bracket to ensure that the socket is fitted so as not to be facing upwards. The bracket shall also ensure the socket outlet does not move when used.

6.2.5 Island Furniture

Where furniture is located away from a wall or column, such as remotely positioned series of workstation, the permanent installation shall be terminated within a floor box or service pole. The soft wiring installation can then be connected to these fixed and permanent service positions.

Service poles should be fixed, top and bottom, to the building fabric i.e. floor and slab above.

6.2.6 Installation Method

To ensure compliance of the overall installation the type of installation method is critical, for example; AS/NZS 4703 stipulates cable support spacing, segregation of cables, and protection of socket outlets.

The installer shall ensure that the documented project works maintain compliance with AS/NZS 4703.

6.2.7 Testing and Commissioning

The completed installation shall be tested in accordance with requirements of Section 10 of AS/NZS 4703 and the following University additional requirements;

- Test the operation of the RCD from the last socket outlet on the soft wiring circuit.

- Verify that the correct cable supports and outlet configuration (mounting detail) has been achieved.

The consultant shall ensure that the above requirements are completed by the installation contractor and recorded with the project Operating & Maintenance Manuals.

6.2.8 Installation Certification

On completion of the works ensure that the following information is obtained;

- Installation test results verifying that tests have been completed as stated above. Testing shall be undertaken by a licenced electrician.
- Certification from the soft wiring system installer confirming compliance with AS/NZS 4703 has been achieved.
- Certification from the soft wiring system manufacturer for each component item.
- Certification from the installation contractor confirming compliance with AS/NZS 3000.

A record of the above information shall be added to the Electrical Services O&M Manuals.

6.2.9 Relocations or Modifications

When an existing soft wiring installation is modified or relocated the above requirements shall be maintained. This will require the retesting and certification.

6.3 POWER BOARDS & EXTENSION LEADS

6.3.1 General

The use of extension leads and multi gang power boards are common in this University although should only be restricted for instances where a temporary installation is required. Such devices are considered portable in use and shall be subject to tagging and testing requirements.

6.3.2 Extension Leads

Extension leads shall be compliant with AS/NZS AS3100 and AS/NZS 3120 and shall be inspected prior to use to identify any possible for signs of physical damage. Leads shall be installed to ensure they are not subject to mechanical damage or create a trip hazard.

Leads shall be of a suitable rating or provided with a thermal cut out device.

6.3.3 Power Boards

Power boards are permitted to be used for temporary installation and to service items of low load i.e. test equipment, computers and alike. These devices shall be compliant with AS/NZS AS3100 and AS/NZS 3105.

Power boards shall be fitted with a maximum 1.5m lead complete with thermal cut out. The power board and associated leads shall be inspected prior to use to identify any possible for signs of physical damage.

Leads shall be installed to ensure they are not subject to mechanical damage or create a trip hazard.

Abbreviations

AHF	Active Harmonic Filter
ANSI	American National Standards Institute
ATS	Automatic Transfer Switches
BMCS	Building Management and Control Systems
CCTV	Closed Circuit Television
CM	Campus Management
DB	Distribution Switchboards
DC	Direct Current
DRUPS	Diesel Rotary Uninterruptable Power Supply
ESD	Ecologically Sustainable Design
ELV	Extra Low Voltage
FSSB	Fire Services Switchboard
GEC	General Electric Company
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HRC	High Rupturing Capacity
HSSB	Hydraulic Services Switchboard
HV	High Voltage
IDMT	Inverse Definite Minimum Time
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IPA	Industrial Projects Australia
ISO	International Organisation for Standardisation
LED	Light Emitting Diode
LPG	Liquified Petroleum Gas
LV	Low Voltage
MDB	Main Distribution Board
MEN	Multiple Earth Neutral
MSB	Main Switchboard
MSSB	Mechanical Services Switchboard
NCC	National Construction Code
PCC	Point of Common Coupling
PFC	Power Factor Correction
PVC	Polyvinyl Chloride
RCBO	Residual-current circuit breaker with overcurrent protection
RCD	Residual Current Device
RFI	Radio Frequency Interference
RGB	Red Green Blue

SSO	Switched Socket Outlet (sometimes formerly known as GPO)
UPS	Uninterruptible Power Supply System
USB	Universal Serial Bus
UWA	The University of Western Australia
WADCM	Western Australian Distribution Connection Manual

References

ACMA	Customer Cabling Rules & Requirements
AS/NZS 1158	Lighting for roads and public spaces
AS 1319	Safety signs for the occupational environment
AS/NZS 1680	Interior Lighting
AS/NZS 1768	Lightning Protection
AS 2067	Substations and high voltage installations exceeding 1 kV a.c.
AS 2293	Emergency escape lighting and exit signs for buildings
AS 2374.1.2	Power Transformers – Minimum Energy Performance Standard requirements for distribution transformers
AS 2676	Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings
AS/ACIF S009	Installation Requirements for Customer Cabling (Wiring Rules)
AS/NZS 3000	Wiring Rules
AS/NZS 3008	Electrical Installations – Cable Selections
AS/NZS 3010	Electrical Installations – Generating Sets
AS 3011	Installation, maintenance, testing and replacement of secondary batteries in Buildings
AS/NZS 3012	Electrical Installations – Construction and Demolition
AS/NZS 3013	Electrical installations – Classification of the fire and mechanical performance of wiring system elements
AS/NZS 3080	Telecommunications installations - Generic cabling for commercial premises (ISO/IEC 11801:2002, MOD)
AS 3953	Loading guide for dry-type power transformers
AS 4282	Control of the obtrusive effects of outdoor lighting
AS/NZS 5000	Electric cables – Polymeric insulated
AS/NZS 5033	Installation and safety requirements for photovoltaic (PV) arrays
AS 60044.1:2003	Instrument transformers – Current transformers
AS 60044.2:2003	Instrument transformers – Voltage transformers
AS/NZS 60076	Power transformers
AS/NZS 60079	Explosive atmospheres AS 60529 Degrees of

protection provided by enclosures (IP Code)

AS/NZS 60947	Low-voltage switchgear and controlgear
AS/NZS 61000	Electromagnetic compatibility (EMC)
AS/NZS 61439	Low-voltage switchgear and controlgear assemblies
AS 62271	High-voltage switchgear and controlgear
AS 62053-21	Electricity Metering Equipment
EIA-485	Communication standard for EIA-485 (RS-485) installation
IEC 62053-21	Electricity Metering Equipment Particular Requirements
ISO 8528	Reciprocating internal combustion engine driven A.C. generating sets

National Construction Code of Australia

Group of standards governing the Modbus Protocol

- Modbus Application Standard V1.1b
- Industrial Communication Network Profiles IEC 61784
- Fieldbus IEC 61784

Change Log

It is envisaged that revisions to this document will be undertaken at intervals of not more than two (2) years. This version differs from the previous version in the following areas:

Section	Title	Description
2.3.1	General Provisions	New section
2.3.2	General Offices	Edited for clarity
2.3.3	Teaching Spaces and Lecture Rooms	Added new info regarding assessments for projects
2.3.4	Laboratories	Added new info regarding power
2.3.5	Data Facilities and Communications Rooms	Paragraph moved
2.3.6	Plant Rooms	Reviewed with minor changes only
2.4	Energy Conservation and Sustainability	Paragraph added
2.6.3	Shutdowns	Need to get approval for shutdown added
2.6.5	Access to Electricity Infrastructure	Paragraph added
2.7	Metering	Meters to be integrated with Revata energy management system
2.7.3	Energy Management, Power Quality and ESD	Added new info regarding Independent Commissioning Agent (ICA)
2.8.7	Cable Conduits & Pathways	Edited for clarity
2.8.7	Access Control	Paragraph removed
2.9.1	Transfer Switching	Last paragraph edited for clarity around priority of load retention
2.9.2	Standby Generators	Added new info regarding portable load bank connection.
2.9.3.	Static UPS	Added new info regarding battery
2.9.3.	UPS Maintenance	Added new info regarding UPS loads.
2.11	Switch rooms	Minor amendments to various sections
2.11.16	Concrete Cable Trenches	Unnecessary text removed for clarity
2.12.4	Inspection and Testing	Edited for clarity
2.12.7	Essential Safety Services	Edited for clarity
2.13.3	Lightning Protection	Added new info regarding minimum surge protection
2.13.4	Surge Protection	Unnecessary text removed for clarity
2.14	Low voltage Wiring Systems	Edited for clarity
2.14.1	Submains	Edited for clarity
2.14.2	Final Sub circuit Cabling	Added new info regarding Communication and IT equipment
2.14.4	Fire Rated Cable Systems	First paragraph reworded for clarity
2.14.7	Trenching	Minor edits for clarity
2.14.7	Cable Pits	Minor edits for clarity
2.15	Seismic Restraints	Minor edit to first paragraph for clarity
2.16	Earthing	Minor edit to last paragraph

2.17.1	Lighting - General	Minor edit to first paragraph for clarity
2.17.3	Luminaires	Minor edits for clarity
2.17.5	Lighting Control	Minor edits for clarity
2.17.6	Emergency Lighting	Minor edits for clarity
2.17.7	Exterior Lighting	Minor edits for clarity
2.18.2	Emergency Stop Isolators	Minor edits for clarity
2.19.2	Light Switches and Power Outlets	Minor edits for clarity
2.20	Variable Speed Drives	Minor edits for clarity
2.21	BMCS integration	Minor edits for clarity
2.23	Redundant Cabling and Equipment	Minor edits for clarity
2.25	Testing, Commission and Certification	Minor edits for clarity
2.26	As installed documentation and operations and maintenance manuals	Minor edits for clarity
3	Checklist for Project Team	Minor edits for clarity
4.1	Preferred Supplier List	Minor edits
Various	In a number of sections the word ‘should’ has been amended to ‘shall’.	
Various	Reference to the latest UWA campus planning documents	
Various	Campus Management Section names have been updated to reflect current structure	
6	New Section on Soft Wiring System Standards Brief	

Appendix A: Sample Power Meter Commissioning Sheet

Power Meter Commissioning Sheet						
Site Information				**Function Commissioning**		
Site				**Function**	**Operational**	**Indication**
Meter Location				**Voltage readings**		
Meter Label				**Current readings**		
Service Metered				**Power readings - demand**		
Meter Details				**Power readings - consumption**		
Manufacture				**Phase 1 CT**		
Model				**Phase 2 CT**		
Serial Number				**Phase 2 CT**		
Wiring Configuration				**Phase 1 Voltage**		
CT Ratio Primary				**Phase 2 Voltage**		
CT Ratio Secondary				**Phase 3 Voltage**		
VT Ratio Primary				**Meter Screen**		
VT Ratio Secondary				**Meter Function Selectors**		
Wiring Check	**Pass**	**Fail**		**CT Links**		
CT Wiring				**Potential Fuses**		
Potential and Potential Fuse wiring				**Serial Port**		
Communications Parameters EIA-485	**Pass**	**Fail**		**Network Port**		
Com Port No.				**Function 1**		
Protocol				**Function 2**		
Baud Rate				**Function 3**		
Parity				**Function 4**		
Unit ID.				**Function 5**		
Communications Parameters IP	**Pass**	**Fail**		**Function 6**		
IP Address				**Function 7**		
Sub-Net Mask				**Function 8**		
Default Gateway				**Function 9**		
Comments: (Faults, Remedial Actions)						
Commissioning Technician Name:						
Date / Time:						
Company:						
Signed:						

Appendix B: Sample Power Meter Verification Sheet

Power Meter Verification Sheet							
Site Information		**Function Verification**					
Site							
Meter Location							
Meter Label							
Service Metered							
Reference Instrument Details			**Phase 1**	**Phase 2**	**Phase 3**	**Neutral**	**Total**
Manufacture		**kW**					
Model		**kVA**					
Serial Number		**kVAR**					
Reference VT Range		**PF**					
Reference Voltage Scale							**Average**
Reference CT Range		**Current**					
Reference Current Scale		**Voltage L-N**					
Reference Neutral CT Range		**Frequency**					
Reference Neutral Current Scale			**Phase 1/2**	**Phase 2/3**	**Phase 3/1**		**Average**
Date of Last Calibration		**Voltage L-L**					
Meter Details			**Phase 1**	**Phase 2**	**Phase 3**	**Neutral**	**Total**
Manufacture		**kW**					
Model		**kVA**					
Serial Number		**kVAR**					
Meter Parameters		**PF**					
Voltage Scale							**Average**
CT Scale		**Current**					
Neutral Scale		**Voltage L-N**					
Parameter 1		**Frequency**					
Parameter 2			**Phase 1/2**	**Phase 2/3**	**Phase 3/1**		**Average**
Parameter 2		**Voltage L-L**					
Comments: (Faults, Remedial Actions)							
Commissioning Technician Name:							
Date:							
Time:							
Company:							
Signed:							