Principal's Requirements
Attachment A – General and Electrical requirements

1 Document Purpose

This document provides details of the electrical standards and equipment requirements that the plant must meet.

2 Definitions

Unless explicitly stated in this document, or the Principal Requirements, definitions are as per the Standards.

8P8C	8 Position 8 Contact (commonly known as RJ45)
AC (or "ac")	Alternating Current (in R.M.S. value unless stated otherwise)
ACMA	Australian Communications and Media Authority
ADSS	All-Dielectric, Self-Supporting (referring to fibre optic cables)
AS	Australian Standard
CA	Communications Alliance
CB	Circuit Breaker
DC (or "dc")	Direct Current
DDF	Data Distribution Frame
ELV	Extra-Low Voltage
EPC	Engineer Procure Construct
FOBOT	Fibre Optic Break Out Tray
FRP	Fibre Reinforced Plastic
GDMS	Generation and distribution management system
HMI	Human Machine Interface
HV	High Voltage
I/O	Input/output
ICT	Information and Communications Technologies
IED	Intelligent electronic device
IO	Inputs and Outputs
IP	Internet Protocol
IP	Ingress Protection
ISO	International Organisation for Standardisation
ITU-T	International Telecommunication Union – Telecommunications Standardisation Sector
LAN	Local Area Network
LC	Little Connector (sometimes Lucent Connector)
LFI	Low Frequency Induction
LV	Low Voltage
MDF	Main Distribution Frame
MIPP	Modular Industrial Patch Panel
MTBF	Mean Time Between Failure
NTD	Network Termination Device
OIC	Officer in Charge
OPGW	Optical Ground-Wire
OPUC	Optical Underground Current
PoE	Power over Ethernet
RJ45	Registered Jack 45
RTU	Remote Terminal Unit
SC/APC	Square Connector / Angled Physical Connection
SCADA	Supervisory Control and Data Acquisition
SFP	Small Form-factor Pluggable
SiD	Safety in Design
SLD	Single Line Diagram
TPL	Tonga Power Limited
WHS	Workplace Health and Safety

3 Standards

All equipment shall be installed and all work shall be carried out in accordance with statutory requirements. Where explicit regulations are not applicable, all equipment and works supplied shall conform to the latest editions of relevant Australian or international standards. The following order of precedence shall apply:

- Australian standards
- International Electrotechnical Commission (IEC) standards, and International Standards Organisation (ISO) standards
- British Standard (BS)
- Institute of Electrical and Electronics Engineers (IEEE) standards

Key standards include, but are not limited to:

Mechanical

- AS/NZS 1170 Structural Design Actions
- AS 1345 Identification of the contents of piping, conduits and ducts
- AS/NZS 1554 Structural Steel Welding
- AS/NZS 4680 Hot-dipped galvanized (zinc) coatings on fabricated ferrous articles
- AS 1657 Fixed platforms, walkways, stairways and ladders
- AS 1796 Certification of welders and welding supervisors
- AS/NZS 2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings.
- AS 2700 Colour standards for general purposes
- AS 4100 Steel structures
- AS 3600 Concrete Structures

Electrical

- IEC 60688 Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals
- AS 1931 High voltage testing techniques
- AS 60529 Degrees of protection provided by enclosures (IP Code)
- AS/NZS CISPR 11 Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement
- AS 2373 Electric Cables – Twisted pair for control and protection circuits
- Electricity (Safety) Regulations 2010
- AS/NZS 3000 Electrical Installations Known as the Australia / New Zealand Wiring Rules
- AS/NZS 3008 Selection of cables Known as the Australia / New Zealand Wiring Rules
- NZECP 34 New Zealand Code of Practice for Electrical Safe Distances
- AS/NZS 3008 Electrical installations - Selection of cables
- AS 61439 Low voltage switchgear and control gear assemblies
- AS 2067 Substations and High Voltage Installations Exceeding 1 kV AC
- AS/NZS 4853 Electrical Hazards on Metallic Pipelines
- AS 4777.2 Grid connection of energy systems via inverters – Inverter requirements.
- AS/NZS 5033 Installation and safety requirements of photovoltaic (PV) arrays

ENA Guides

- ENA EG0:2010 Power System Earthing Guide
- ENA EG1:2006 Substation Earthing Guide

IEEE Standards

- IEEE Standard 80 (2000): Guide for Safety in AC Substation Grounding
- IEEE Standard 837 (2002): Qualifying Permanent Connection Used in Substation Grounding

Drafting and Design Standards

- AS/NZS 1100.101-501 Technical Drawings
- IEC 60027.4 Letter symbols. for use in. electric technology
- AS 1101(series) Graphic symbols for general engineering
- AS/NZS 1102(series) Graphical symbols for electrotechnical documentation
- IEC 60848 Specification language for sequential function charts
- AS/NZS 4383 Preparation of documents used in electrotechnology

In case the equipment or materials offered from a country where the relevant standards to which the equipment or materials offer better performance or safeguards for the Principal than the relevant AS, IEC or ISO specifications, these are acceptable. The Contractor must substantiate any such claims by submitting an independent assessment, by an appropriately qualified person, that identifies differences in the standards and demonstrates the benefit for the Principal.

All listed standards must be complied with unless exception is granted, or noted in these Principal Requirements. If a requirement included in the Principal Requirements exceeds a standard listed, then the requirement within the Principal Requirements shall be adhered to.

Standard(s) referred to shall mean the current Edition / Revision together with Amendments issued.

4 Proposal inclusions

The Contractor shall provide the following in the offer as applicable to the scope:

- Technical description of the proposed system and products.
- Concept diagrams of the system
- Product technical data sheets, user manuals, and other technical documents that are required to understand the proposed functionalities.
- SCADA screen examples
- Product road map.
- Bill of material.
- Commercial schedules.
- Schedule of deviation from tender. (if applicable)
- Delivery lead-times.
- Cutover strategy
- Outage durations

5 High level details

At a high level the scope of works for this engagement will include but not limited to the design, procurement, installation, testing and commissioning of a GDMS (Generation and distribution management system) which will comprise of SCADA applications, hardware, software and data networks implemented to ensure system redundancy, reliability and security with no single point of failure.

The system will be capable of allowing TPL to monitor and control TPL's existing and future generators and network assets from two physically separate control centres. Servers will be located in TPL Office Building at Manatoa. The system will interface to new and existing RTUs through different mediums of communication to the stations such as direct Ethernet, satellite, radio or cellular.

The Master Station shall also be implemented with Generation Dispatch and Control which will include an Automated Generation Control (AGC) application to control energy dispatch, system frequency and time deviation.

The Master Station shall also include a training simulator which would be used for basic operator training and familiarisation of the system initially, with plans in the future to expand for an Advanced System Simulator. This system shall include provisions for future applications such as Distribution Management and Outage Management. These applications shall be tightly integrated with the SCADA system.

The control centre operators shall be able to remotely control and monitor all generating assets in the network.

The SCADA System application shall include but not limited to:

- SCADA visualisation
- Alarm Processing
- Trending
- System configuration management tool
- Sequence of events
- Calculations (periodic and demand)
- Calculation Scripting
- Event search
- Display Builder
- Generation Dispatch and control

The Master Station system implementation works shall include but not limited to:

- Drawings for the system and interfaces to external connections
- Configurations, databases and programs for system
- Master Station Functional specification
- Procurement of required equipment and associated equipment/consumables.
- Factory/Site Acceptance Testing and documentation
- Installation
- Training

6 Project Execution

The contractor shall submit to the owner four weeks after award of the contract the project execution plan for review. This shall include the following documents:

A Project programme shall provide sufficient detail to enable the owner to co-ordinate the activities of the contractor with the owner's staff and other contractors. This shall be in a Gantt chart format using Microsoft Project.

A Quality assurance plan to ensure the quality of all design and implementation works required under this contract meets the design and performance requirements specified in this document. The Contractor shall follow the requirements of the ISO 9000 series – Quality Assurance.

A Health and safety plan to cover, but not limited to, the following:

- Safety policy
- Company standards
- Project safety programme
- Hazard identification
- Occupational safety and health
- Accident and emergency procedures
- Crisis management plan
- Environmental management plan
- Operating methods and procedures
- Auditing plan and procedures
- Permit to work procedures

6.1 Project Schedule

Bidders shall include a hard copy (Gantt Chart) for their proposed schedule. It is anticipated that the award date will be within the Bid Validity period, with the project being completed within 18 months.

The project schedule shall include the following hold and witness points.

6.2 Meetings

The Contractor must allow for the following meetings, at a minimum:

Meeting description	**Location**
Kick-off meeting	May be video conference or on site
HAZOPS	May be video conference or on site
Safety in design review at 30% design stage	Video conference
30% design review meeting	Video conference

Weekly or fortnightly (as needed) engineering meetings to clarify information or issues arising in the design process	Video conference
80% design review meeting	Video conference
Daily / weekly prestart meetings	On site
Fortnightly quality meetings during construction to discuss and resolve site issues	Video conference, including site representative
Initial training sessions with local staff (minimum 3 days)	On site

6.3 Hold Point Summary

A Hold Point is defined as a stage in the process of delivering the work under the contract, beyond which work must not proceed to the next activity without written approval.

The contractor shall allow for a 14 day review period from TPL after the submission of any deliverable. This does not constitute certainty of approval.

6.4 Progress reporting

The Contractor shall provide brief fortnightly reports to the owner by email during the entire design, procurement and construction period. These reports shall include as a minimum the following:

- Project name
- Progress to date
- Expected progress next fortnight
- Updated schedule
- Invoicing to date
- Risks

6.5 Hold point summary

A Hold Point is defined as a stage in the process of delivering the work under the contract, beyond which work must not proceed to the next activity without written approval.

The contractor shall allow for a 14 day review period from TPL after the submission of any deliverable. This does not constitute certainty of approval.

Hold Points are contractual obligations. The following table provides a summary of the Hold Points:

Section	Brief description
Design Drawings	Design drawings to be accepted prior to manufacture commencing.
Procurement list – major items	Including order codes, to be reviewed by TPL prior to procurement.
Master Station high level specification and architecture	To be prepared at the start of the design process.

HMI screen samples	To be prepared during detailed design, prior to the completion of the SCADA design.
SCADA signal lists	To be prepared during detailed design, prior to the completion of the protection settings
Inspection and Test Plans	The Inspection and Test Plans shall be submitted for approval a minimum of 4 weeks before FAT.
Factory Testing	All factory testing shall be deemed to be a Hold Point unless otherwise advised in writing.
Other	Additional "HOLD" points may be nominated when the manufacturing and test program is known.

6.6 Witness Point Summary

A Witness Point is where notification is required that a particular process or activity is available or ready for inspection.

Witness Points are contractual obligations. The following table provides a summary of the Witness Points:

Section	**Brief description**
Factory Testing	All factory testing shall be deemed to be a Witness Point unless otherwise advised in writing.
Site Testing	All site tests shall be witnessed (If applicable).
Other	Additional Witness Points may be nominated when the manufacturing and test program is known.

7 Detailed Design

7.1 Design process

The contractor shall provide the detailed design based on the approved design schedule.

The contractor shall not procure any item of equipment until the corresponding detailed design has been approved by TPL.

The detailed design shall be broken down into packages which may expedite the procurement for long lead items if early approval by TPL is achieved

The contractor shall allow for a 14 day review period from TPL after the submission of any design package. This does not constitute certainty of approval.

7.2 Design Documents

The contractor shall produce the following design documents as a minimum for approval:

Specification - High Level Design - Architectural and Technical

- Specification - Recommendations on Control Room(s)
- Specification - Software Design including Alarm Management, Generation Dispatch and Control
- Specification - Business Delivery - Integration Requirements Specification
- Software Design Specification - How-To Manual
- Specification - SCADA Graphical User Interface (or HMI) Specification
- Major Equipment Data sheets
- Calculations - Design Calculations - Processing Capacity & Capability, Storage Capacity, UPS Max Demand, Cable Selection
- Communications cable schedule
- Master Station functional description
- Master Station Architecture
- SCADA displays and databases
- SCADA points list
- IP address list

7.3 Drawings

7.3.1 General requirements

- All documents that are to scale shall have a scale block.
- Where scales are used, they shall be to the applicable Australian Standards.
- Use TPL drafting standard and drawing template.

7.3.2 Title Block

- All drawings shall have a title block.
- The title block shall be in the bottom right-hand corner of the drawing.
- Use shall be made of a standard template for title blocks as supplied by TPL. This template shall not be modified.
- An area will be provided in the TPL title block for the Contractor's name, logo, number, etc.

7.3.3 Numbering

- The Contractor shall number the drawings based on project number, type of drawings and sheet number.
- TPL will register the completed drawings upon receipt in their own drawing management system and provide each drawing with a unique number.

7.3.4 Size

The final presentation of drawings on paper or equivalent media should be A1 or A3 size only.

All printed and electronic drawings shall be legible for the intended conditions of actual use and sheet sizes shall be selected taking into account:

- Legibility
- Complexity of design
- Number of sheets required for finished project
- Finished Storage requirements

7.3.5 Presentation of drawings

- Three sets of hard copy drawings
- Prints of drawings shall be full-sized paper reproductions made by an electrostatic process or equivalent in non-fading ink.
- Electronic copies of the drawings shall be provided in a format compatible with the latest version of AutoCAD.
- The drawings shall be presented on a CD-ROM together with a full index for the disk listing drawing titles and numbers.

7.3.6 Layout

- Consideration shall be given when preparing drawings to adopt clear layout that is easily understood.
- Flow direction should read from left to right or from top to bottom.
- In any set of drawings only one projection method should be used.

7.3.7 Legends, Schedule and parts lists

- Legends shall be included in the title block if room allows, otherwise a separate sheet can be included.
- All symbols used on a set of drawings shall be tabled with a description.
- Where several parts or schedules are detailed or an assembly of parts is shown, a tabulated parts list shall be shown above the title block or on a separate sheet.

7.3.8 Wire and device numbering

- All electrical drawings shall use standard symbols complying with applicable Australian/NZ Standards.
- Wire numbering is to follow the wire numbering code as detailed in Appendix D of AS2067.
- Device numbers shall be allocated such that each piece of equipment or device at a particular site has a unique identifier.
- Device numbers shall comply with TPL's requirements.
- Equipment shall be identified by a device number on all drawings.

7.4 Cable schedules

7.4.1 General requirements

The Contractor shall prepare new or update existing cable schedules to show all cables added or modified for the Contract.

Cable schedules shall show for each cable:

- Cable identification number

- From/To information showing the location of the two cables ends in separate columns by cubicle designation or device description with, where applicable, the device number as shown on the circuit diagrams.
- Details of the cable (type, conductor size, number of cores, route length in metres).
- Type and size of cable glands.

7.4.2 Format

- The cable schedule shall be provided in both electronic (Excel, Word, PDF) and hard copy.
- The hard copy sheet sizes shall be selected taking into account legibility for the intended conditions of use.

7.5 As-Built drawings

All documents and drawings created as part of the detailed design shall be As-built and issued to TPL within four weeks of practical completion of the works.

All documents and drawings shall be provided in both pdf and their native formats.

7.6 Formats

The Contractor shall provide all necessary project documentation and drawings, in the English language, in appropriate electronic formats.

Standard SI units shall be used throughout all of the design.

Deliverables should be issued electronically in PDF format. The final construction package submission should be issued in both PDF and native electronic formats.

Native versions of deliverables shall be in the following formats:

- CAD files in AutoCAD 2010 format;
- Spread sheets in Microsoft Excel 2010 (.xls or .xlsx) format;
- Text in Microsoft Word 2010 (.doc or .docx) format;
- OEM documentation in PDF;
- Schedules in Microsoft Project 2010.

8 General technical requirements

The following table provides general climatic and environmental conditions in Tonga

Parameter	Details
Location	Tonga
Altitude Nuku'alofa	3.05M
Maximum ambient temperature	32.2C
Rainy period	February has the most rainfall-November being the driest month
Cyclonic conditions	More prevalent between February to April

8.1 Materials

Any product or materials supplied for this project shall be supplied to comply with the following:

- Be new and approved by the Engineer
- Be the latest version of the device
- Be supplied with appropriate software
- Be suitable for the intended use
- Have a proven track record in similar installations
- Be compatible with other associated equipment
- Be supported by local suppliers or agents
- Be designed to operate in the environment it is to be installed in
- Be suitable for installation in to areas that are accessible for maintenance
- Have the manufacturers label attached
- Be protected against the electrolytic corrosion due to the action of dissimilar metals.
- No part of the equipment shall incorporate:
- Asbestos or asbestos-containing or derived materials;
- Lead based paints;
- Isocyanates;
- Polychlorinated Biphenyl's (PCBs);
- Chloro-Fluoro Carbons (CFCs) including Halon and Freon or other ozone depleting substances;
- Carcinogenic materials, including hydrazine;
- Toxic inhalation hazard chemicals;
- Cadmium plated nuts and bolts;
- Radiation materials;
- Any other materials generally known in the construction industry at the time of use to be deleterious to health.

Materials supplied shall be as specified or an approved equivalent.

8.2 Control Cabinets

The Control Cabinets scope shall include the following:

1. Supply of the PLC cabinets for the installation in accordance with the following specific and common drawings, completely wired with all terminals, and ancillary equipment

2. Supply and installation of all PLC components, backplanes, connectors, terminators, power supplies and the like
3. Supply and installation of the associated 24Vdc charger, battery, and DC distribution systems
4. Supply and installation of the associated fibre terminations and connection systems, fibre patch lead, and fibre to copper converters, copper patch leads, network switches and the like
5. Provision of any workshop drawings where the designs are altered from the arrangements provided herein
6. Inspection and testing plans and testing documentation
7. Assembly at the manufacturer's works and first livening
8. Allowance for a hardware Factory Acceptance Test (FAT) at the manufacturer's works by the Principal and their representatives
9. Delivery to site following acceptance by the Principal of the manufactured panels

8.2.1 Indoor Control Cabinets

Summary of key component specifications below;

- Dimensions – As required by Contractor Design
- Colour – Light grey
- Cabinet Rating – IP65
- All equipment mounted on a removable painted gear plate
- Full width two piece undrilled aluminium gland plate
- Plinth for floor mounted cubicles
- Strengthened backplate or superstructure for wall mounted units
- Three point securing location lockable doors with lockable operating handles
- Earth bar and copper earth straps to all doors
- External panel label (traffolyte or similar)
- No nickel fittings, nor exposed copper
- Internal wiring secured in slotted cable PVC trunking
- Plinths;
    - PLC Cabinets – 100mm x 50mm steel channel (minimum)
    - Gland Plates – Aluminium
- PLC Cabinets to be complete with;
    - Internal lights (one per cubicle) operated from door switches
    - RCD GPO
    - Thermostat and Heater
- Equipment Labels;
    - All internal equipment to be labelled (PLC, PLC cards, communications equipment, IO termination blocks, monitoring equipment, power supplies etc.) – engraved traffolyte
    - Exterior labels – engraved stainless steel

8.3 Cabling and cable management

All cables shall be designed and installed in accordance with the Standards.

Additionally:

- Cables shall be labelled at both ends, with permanent labels.
- Above ground cabling shall be placed and protected such that DC clamp meters can be used to confirm no current flow for safety isolation purposes. No tools shall be required to allow such cable access. Service loops shall be placed in all cables external to the combiner box to allow re-termination if required.

- All outdoor enclosure cable entries are to be done from the bottom of the enclosure, to prevent water ingress.
- For underground cables, cable markers shall be installed at each change of direction, road crossing, and every 200 m of straight line length. Cable markers should designate the underground service details, depth, and relevant contact details. Cable markers should be selected to last the design life. Cable markers should be sensitive to the location (for example, flush mounted where they would obstruct other activities) and agreed with the Principal.
- Underground cables shall be protected from damage by vermin. A termite-protection layer shall be included in all underground cables. Water blocking shall be included in all underground MV cables.

8.4 Fixings and fasteners

Any fixings and fasteners should give consideration to corrosion requirements. Dissimilar metals should be avoided and otherwise separated by nylon washers.

1. and equipment specifications

9 Site requirements

This section sets out general expectations for site works. These are in addition to any conditions of regulatory approvals for the project.

All site works must be completed by qualified and competent technical people, the contractor must adhere to all TLP OH& S policies and procedures.

9.1 Work Practices

The Contractor will submit a set of work practices applicable to this project along with the general Health and Safety plan before site mobilization. The procedures will be subject to acceptance by the Principal. The procedures shall meet the following requirements.

9.1.1 Mobilisation & Demobilisation

Mobilisation and demobilisation shall include but not be limited to the following:

- Supply, installation and maintenance of Contractor's Site office and facilities;
- Mobilisation of all facilities, construction plant and personnel necessary for the Works; and
- Demobilisation of all facilities, Plant and Equipment and Contractor's Personnel from Site, and the rehabilitation of all Temporary Work Sites to the approval of the Principal.

The Contractor shall be responsible for the mobilisation of personnel, with flights provided by the Client. All personnel shall mobilise to the Project having completed a 'Level 1 Pre-placement Medical' and having had a Police Clearance lodged. The Contractor shall provide evidence of this documentation to the Principal prior to mobilisation of personnel.

9.1.2 Test energy

Test energy for initial pre-commissioning tests once equipment is connected to the grid will be provided free of charge by the Principal.

9.1.3 Site Access and Vehicle Parking

The Contractor shall utilise only existing site access and vehicle parking areas, unless by prior approval by the Principal. The Contractor shall liaise with the Principal to ensure that access to the site and the daily business operations of the Principal, community members, and other contractors are not adversely affected.

9.1.4 Laydown and Security

The Contractor is permitted to use the specified sites for laydown or equipment storage as may be required. Use of any other areas for laydown, storage, parking, or other such activities is generally not permitted, except by express consent of the Principal.

9.1.5 Site Clean Up

The Contractor shall make every effort to keep the Site of Works in a clean and tidy condition for the duration of the Works. The Contractor shall, from time to time, and on completion of any area of the works or where directed by the Principal, remove rubbish, surplus materials or any other construction debris from such areas as may be attributable to the Work under the Contract and generally leave them in a satisfactory condition and to the approval of the Principal.

Upon completion of the Works, the Contractor shall remove all rubbish, debris, temporary earthworks or surplus materials from the site of the Works. The site shall be left in a neat and tidy condition to the satisfaction of the Principal.

9.1.6 Site Meetings

The Contractor shall provide for its relevant staff to attend required meetings with the Principal at the project site or the Principal's offices for the duration of the Contract. Consideration will be given to remote meetings (teleconference / videoconference) for instances where it can be shown that these will not affect the satisfactory outcomes of the meeting.

9.2 Miscellaneous requirements

9.2.1 Contactor's Personnel Qualifications

Contractor shall provide the names of the nominated Site Supervisor for each site, and other site personnel. The Contractor shall also provide evidence of qualifications, including:

- Contractor's general safety induction and site specific induction
- Formal first aid training, including CPR - must be at least two qualified First Aid personnel on each site
- Qualification or endorsed training as applicable to work being undertaken, including but not limited to:
    - All LV electrical works by qualified electrician
    - All works on proprietary components to be conducted by personnel meeting OEM requirements
    - Communications installations, including fibre terminations, by trained and experienced technician
    -

9.2.2 Workmanship and Materials

Workmanship shall be of first class commercial quality and in accordance with the best shop practice. Like parts shall be interchangeable. Machining of fits on renewable parts shall be accurate and shall be to specified dimensions, so that replacement parts may be readily installed.

Unless otherwise specified, materials and components used for the Works specified shall be new and unused. Materials and components shall conform to the standards current at the time of execution of the Agreement.

9.2.3 Packing and Shipping

9.2.3.1 Packing

All items of Plant supplied by the Contractor shall be adequately packed and protected for shipment and outdoor storage at Site.

The Contractor shall ensure that the Plant shall be protected against corrosion, weather damage, condensation, distortion, and damage by vermin and the ingress of foreign matter.

Packing of any Plant shall comply with the approved shipping preparation and packing procedures and shall include but not be limited to the following:

- Plant shall be properly packed.
- Plant shall be shipped in weather proof and watertight containers unless otherwise agreed with the Principal.
- Containers, crates or packages shall be checked for defects internally and externally prior to packing.
- Weights and lifting points shall be clearly visible on each package.
- Plant shall be not wrapped in plastic unless it is coupled with adequate moisture absorbent material, such as silica gel and the like.

- Bright metal parts shall be greased coated or similar rust inhibitor applied commensurate with the type of machinery.
- Machined surfaces shall be protected with wood blocks or similar approved means and reinforced externally with metal bands or plates.
- Exposed threaded joints shall be encased or plugged as required.

For imported components, packing material shall comply with import and export regulations. All wood packing in each consignment shall be free from bark and all visible signs of insect and fungal attack at the time of shipment. Furthermore, the importation of packing materials such as second-hand sacking, hays, straw, chaff, rice husks and peat shall be prohibited. The Contractor shall be responsible for obtaining approval of the packing timber and materials before delivery. Packing lists shall state the type of packing used and certify that none of the prohibited material has been included.

The Principal may require to inspect and approve the packing before the items are dispatched but the Contractor shall be entirely responsible for ensuring the packing is suitable for transit and such inspection shall not exonerate the Contractor from any loss or damage to faulty packing.

Waste packing material, and in particular non-biodegradable waste material such as plastic packaging, shall be minimised.

9.2.4 Unloading and Storage at Site

The Contractor shall at Site place the equipment in the Contractor's storage area in the following manner:

- Place any containers or any packages in locations as directed by the Principal.
- Certify that the contents of any container or any package agree with the said packing lists.
- Remove from Site any unwanted packing debris and any empty containers immediately after completion of unloading at Site.

9.2.5 Existing Works and Underground Services

The Contractor may rely on map of Buried Services for the site area. However, the Contractor shall note that the drawings of existing services may contain inaccuracies. To ensure a safe approach, the Contractor shall ascertain the location of any buried services in the vicinity of the Works before commencing construction. If services are identified, then the Contractor shall give notice of this to the Principal at least three (3) working days prior to the commencement of any construction activity that may affect those services(s).

The Contractor shall take all reasonable actions and provide all things reasonably necessary to protect and maintain existing services to the satisfaction of the Principal. In the case of damage occurring to existing services, the Contractor shall immediately report the damage to the Principal. The cost of the necessary repairs or renewals shall be borne entirely by the Contractor.

If it is found to be necessary to alter the location or level of any existing services to conform with the Works, the Contractor shall relocate, redirect or alter any existing services as required to execute the Works and to the satisfaction of the Principal. This will include altering finished surface levels of existing services.

If uncharted services are encountered during excavation, the Principal shall be notified before proceeding.

Any connections to live equipment will only be permitted with the consent and under the supervision of the Principal. The Contractor shall notify the Principal prior to carrying out any such work, detailing the method to be employed.

Any connection requiring statutory or other approvals shall be the Contractor's responsibility.

9.2.6 Services Shutdown

Where it is a requirement to temporarily shutdown or disconnect services (such as electricity or water) for the completion of the works the Contractor shall notify the Principal at least three (3) days prior.

Generally the Contractor will be required to undertake shutdowns to coordinate with site operations and minimise any disruptions to normal operations.

The Contractor will have been deemed to have included all costs associated with any shutdowns in the agreed Contract Sum.

9.2.7 HV Switching and Isolations

The Principal will provide/organise for all HV switching and isolations for equipment connections. The Contractor shall provide a minimum of five (5) working days' notice for HV equipment isolation requirements.

9.2.8 Structural Integrity

The Contractor shall be responsible for ensuring the structural integrity of any temporary works, and of any existing works where impinged upon by new works.

9.2.9 Hazardous Areas

No sections of the installation are within hazardous areas or require hazardous equipment ratings.

9.2.10 Site Clearance and Demolition

All equipment isolations will be completed by Principal's Power Station staff in conjunction with the Contractor.

The Contractor shall carry out all decommissioning necessary to complete the Works and shall be responsible for the removal and disposal as directed by the Principal of all demolished and decommissioned equipment.

9.2.11 Site Induction Requirements

The Contractor shall be required to comply with all of the site requirements including compliance to all isolation, induction, site safety, first aid, and emergency procedures. The Contractor shall ensure that all site personnel have all of the requisite certification for site.

9.2.12 Community relations

Contractor will take advice from the Principal, obtaining a full brief of current situations and establish a plan that will complement the established management approach and leave zero legacy.

Contractor will adopt the following procurement practices for businesses in the region, where possible:

- acquire goods and services from local industry where local industry is able to provide those goods and services at equal to or of better standards of competency, capability and commerciality as those from outside of local industry;
- give local industry a reasonable opportunity to submit proposals and tenders when requests for proposals and tenders are made and consider local industry when addressing preparation of specifications, calling tenders and letting contracts for the acquisition of goods and services; and
- use best endeavours to engage labour from the local area where those persons have the requisite skills and are available on equal or better terms and conditions than labour from outside the local area.

Contractor will be obligated to:

- abide by the local laws and regulations;
- recognise and respect the culture, values and traditions of those communities; and
- behave in a socially responsible manner during both working and after hours.

10 Training and capacity building

The Contractor shall provide Operations and Maintenance training as part of this scope of works. Prior to Completion, the contractor shall conduct Site-specific training for The Principal's-assigned operating personnel. The training course shall be conducted two times to accommodate shift personnel. Each of the two groups shall receive training in alternate weeks. Each course shall be conducted during a standard 8-hour day and shall take between 1 and 2 days depending upon the complexity of the Project and training requirements. Classroom training will be augmented by field reinforcement of the instruction topics. Each training session shall be instructed in an air-conditioned classroom with the appropriate visual aids.

The training program will cover all proper aspects of knowledge required by the individual discipline to allow them to competently operate, troubleshoot, and maintain all Power Plant processes and utility systems.

The Principal shall advise the Contractor one month in advance the number of personnel attending each session. A training sign-up sheet shall document The Principal's personnel attendance and the SCADA supplier's instructor(s). The Contractor will submit its proposed training schedule, training course outline and training manual for the Principal's review. The following training topics shall be covered:

- Architecture
- Site Overview
- Connections
- Data storage & trending
- Operation
- Maintenance & trouble shooting

For each training programme the following shall be provided:

- Types of courses & format
- Duration and period of courses
- Training documentation (manuals/ drawings)
- Training knowledge Pre-requisites

The training agenda must be submitted to the Purchaser, minimum 14 days before the proposed training dates.

11 Environmental and social risk

Requirements for managing environmental and social risk of the project are included in the Scope of works, and any regulatory approvals and conditions for the project.

12 Equipment requirements

All equipment must be selected to ensure it is suitable for site conditions, reliable, compatible with subsystems and equivalent products, readily serviced, and that spare parts are readily available. To this end, all components must be selected from suppliers continuously servicing utilities in major international markets including Australia, Europe and the USA for a minimum of 10 years. Specific products or their product chains must have been offered for at least 5 years, and manufacturers must offer a commitment to support the product for a minimum of 10 years.

12.1 Licenses

The contractor must have all relevant licences, accreditations and permits for the manufacturer and supply of equipment to Tonga. The contractor will provide details including costing of any ongoing licencing requirements for the system to continue to run without issues.

12.2 Design Life

The SCADA system and all associated software, parts, components and accessories must be designed to operate for a Design Life of thirty (30) years without major repairs or retrofits, and all components shall be designed for at least this Design Life.

The integrated solution shall be fit for the intended purpose and for maintaining full performance over the design life and shall include all works necessary for the safe, reliable and efficient operation and maintenance of the SCADA system and associated equipment provided as part of the works.

12.3 SCADA system, PLCs, Control systems, cabinets and junction boxes

12.3.1 General

The Contractor shall implement the following design requirements.

12.3.2 SCADA, PLCs &Control Systems

SCADA, PLCs and Control Systems shall be provided where necessary to monitor, control, display, alarm, and record operation of the installation. The PLCs and Control Systems shall fully integrate with the Principals systems and incorporate comprehensive system diagnostics to assist in maintenance and trouble-shooting.

PLCs and Control Systems shall include processor modules, power supplies, input/output cards, communication cards or any other specialty cards to provide a fully functioning system. The Processor and I/O bus shall have minimum of 25% spare capacity at the end of the commissioning for future works.

The Control systems are to be installed in cabinets or enclosures as detailed in this section.

The PLC and all of accessories including software must be supported for a minimum of 10 years. The contractor shall specify type and brand of PLC and SCADA system in the submission.

12.3.3 Cabinet General Requirements

These control cabinets shall contain PLC or SCADA components, and their standard I/O connections, as well as the fibre, small wiring, AC and DC distribution systems and all of the PLC / control system components.

13 Quality control

The Contractor shall provide a Quality Management Plan (QMP) that describes the quality control methods for manufacture of all major equipment and equipment installation and testing. The scope of the QMP shall include:

- Full production chain of quality assurance
- Subcontracted works and manufactured components of the project
- Comprehensive matrix of testing planned, including FAT, Manufacturer Data Records, and Inspection Test Plans
- Inclusion of checks, witnessing and auditing required for quality control
- Document management for quality assurance documentation.

13.1 Witness and Hold Points

The Contractor shall provide all test plans including recommended Hold and Witness points. The Principal shall have the option to review and nominate additional Hold or Witness Points if reasonably required.

The Principal's presence is required at Witness Points. The Contractor may proceed past the point provided the agreed notice of test (written / e-mail / documented notification) is given and the Principal elects not to be present at the time of the test.

13.1.1 Hold Points

Where Hold Points have been identified by the Principal in the CDRL, no work is to proceed beyond these points prior to the Principal's inspection, and/or prior to the Principal providing approval. Waiver of the inspection can only be given in writing by the Principal

13.2 Inspection and testing

Inspection and testing shall be planned with due consideration for the limitations on site testing, including resources and disruption of the grid. All efforts shall be made to rigorously confirm product quality and performance prior to shipment to site.

13.2.1 Factory acceptance tests (FAT)

The Principal shall have the option to witness[1], or appoint a third party to witness, any testing Major component FAT. At least 10 days' notice of planned testing shall be provided.

Major components shall be subject to FAT including:

- BESS (PCU and Battery modules)
- Solar PV PCU
- PV modules
- Transformer
- Switchgear
- EMS

The FAT shall include pre-energisation (cold test) quality control checks including fabrication, installation, connections, electrical safety tests, and subsystem functionality. These shall ensure installation and equipment is as per specification.

The FAT shall include energised (hot) quality control tests to confirm all operational capabilities and to measure equipment performance in accordance with the functional guarantees.

[1] Witness may include in-person, or remote via video conference. Contractor must be able to provide for either option. Principal witness may include Principal nominated representative.

Energised FAT (for Principal witness if requested) shall not proceed until the Contractor has met the following conditions:

- FAT Plan, including detailed ITP has been provided and reviewed.
- No further work is required to complete the build of the equipment, and, excepting packing or other such requirements to make safe the equipment for transport, the equipment is complete and ready for shipment.
- Evidence is submitted to show that all pre-energisation checks are completed satisfactorily, and that the equipment is fully capable of energisation.
- Evidence is submitted to show that all control programming and bench tests of control systems are complete.

The scope of the FAT shall be sufficient to:

1. Comprehensively ensure that the equipment operates as agreed in the Principal Requirements
2. Ensure that the equipment operates as intended
3. Allow the Principal to observe operation characteristics that may impact integration to the power station

Other components and materials shall be subject to end-of-line testing and factory quality control, and be issued with the associated manufacturer data records. This includes:

- Cables (electrical and fibre)
- Metalwork
- Cabinets and enclosures
- PLCs, control, networking and associated equipment

13.2.2 Inspection and test plans

The Contractor shall prepare Inspection and Test Plans (ITPs) covering all aspects of the works; these shall be submitted to the Principal for review and approval prior to any Inspection and Testing of the works. The Contractor shall carry out inspection and testing in accordance with the best industry practice and manufacturers recommendations.

Commissioning Management Plan. The Contractor must provide the Principal with a Commissioning Management Plan. The Commissioning Management plan must detail the schedule of ITPs and checklists to be provided and the dates on which they will be provided to the Principal.

The Principal reserves the right to inspect the Works to the extent necessary to be satisfied that the work conforms to the drawings and specifications and to verify that all the required testing and inspections have been completed to the satisfaction of the Principal and Client Engineers.

The Principal may appoint an Inspection Agency to carry out inspection services and to witness and verify tests. The Contractor shall liaise and co-ordinate fully with the Inspector and take all necessary measures to facilitate testing and verification.

The ITPs shall clearly define the objectives, any pre-requisites and pass / fail criteria. The pass criteria shall be correct operation. Any failed test shall be registered as a defect or non-conformance (as applicable) and rectified by the Contractor. On the identification of a failed test the Principal reserves the right to halt all further testing until satisfactory remedies have been implemented and recorded.

The ITP shall be marked up during testing and each test signed as completed by the Contractor and witnessed by the Principal (at its discretion). A copy of the signed off ITP and related test certificates shall be delivered to the Principal in electronic form at the successful completion of the tests.

ITPs and checklists are to be signed off progressively as work progresses. ITPs and checklists are required to be submitted to the Principal progressively throughout construction, with test records, completed ITPs and checklists forming part of the verification records for the work and be compiled into the As-Built documentation.

No testing shall commence before the ITP has been approved by the Principal.

13.2.3 Materials handling

Quality control must include materials handling procedures. This includes procedures for:

- Inspection prior to shipment and on receipt at site
- Transport of equipment, loading and unloading
- Storage requirements
- Tracking of equipment and storage locations

Procedures shall include completion of relevant quality control documentation.

13.2.4 Pre-Commissioning Tests

13.2.4.1 General

The Contractor shall carry out Pre-Commissioning Tests on-site following completion of installation of the Plant and prior to completion, in accordance with the Contract. The purpose of the Pre-Commissioning Tests is to confirm that the installation of the Plant is complete and correct, and in a safe condition for livening and operation.

13.2.4.2 Electrical Pre-Commissioning Tests

The Contractor shall pre-commission all of the electrical works.

The Electrical Pre-Commissioning Tests shall include all requisite cold checks, high potential testing, meggering, phasing, insulation resistance, continuity, point to point termination checks, polarity, phase rotation, protection testing and functional operation of all devices and controls.

The Contractor shall provide all suitably calibrated test equipment to perform all pre- commissioning and post livening tests and suitably qualified and experienced personnel to provide the testing.

The Contractor shall provide detailed test sheets for the commissioning of each protection and metering type. The Principal test sheets shall be limited to an overall check sheet encompassing all checks suitable for sign off before livening.

No item of plant shall be livened until clearance is obtained from the Principal, at which time the necessary warning notice in accordance with safety procedures shall be attached to the relevant circuit switch or isolator, and where appropriate, to the plant item itself.

In addition to any testing required under local regulations, the Electrical Pre-Commissioning Tests shall include but not be limited to the following:

13.2.4.2.1 Visual Inspections

Visual inspections shall include:

- Checking plant for conformity with specifications
- Removal of packing or protective materials from instruments, equipment and devices
- Systems complete "component count"
- Switches, fuses and ancillary equipment correctly labelled and set to appropriate current ratings
- Checking all fasteners, fittings, supports, alignments and clearances
- Checking rotation direction of all drives
- Checking of all earthing

- Electrical systems certified for compliance with the relevant standards

13.2.4.2.2 Control and Instrument Cables

Control and instrument cables shall be tested for:

- Continuity
- Labelling
- Terminations against schematics
- Removal against schematics

13.2.4.2.3 Low Voltage Cables

Low Voltage cables shall be tested for:

- Continuity
- Insulation resistance
- Labelling
- Terminations against schematics

13.2.4.2.4 Earthing

Conductivity tests of the system and earthing resistance tests shall be performed at points throughout the system before any electrical equipment is energised from the permanent source of power.

The commissioning testing of the earthing system will include performance testing, continuity testing and visual inspection for design compliance. The objectives of the testing will be to:

1. Verify the safety performance installed earthing system in accordance with ENA Guides and IEEE Standards, and other relevant standards codes, guides and legal requirements
2. Establish bench marks for the earthing system performance for future audits by simulated earth fault current injection tests to determine earth grid voltage rise, step and touch voltages and earthing system impedances
3. Report on the condition of the earthing systems in terms of compliance with the design, standards and to provide a statement of compliance or non-compliance. The intent of the report is to provide a comprehensive assessment of the condition and performance of the earthing systems and provide sufficient information such that remedial action can be arranged based on the recommendations provided in the report.

Physical inspection of the earthing system shall include inspection of the earthing system to determine condition and compliance to design (conductor size, material, connections).

The Contractor shall carry out electrical continuity measurements on the earthing system, to a specific reference point(s), to determine whether plant equipment is adequately earthed in compliance with design and relevant standards.

13.2.4.2.5 Fibre Cables

Fibre cables shall be tested for:

- Optical Time Domain Reflectometer (OTDR) Tests, all cores in both directions;
- Single Mode Fibres: 1310nm and 1550nm
- Multimode Fibres: 850nm and 1300nm
- Insertion loss tests
- Labelling
- Terminations against schematics

13.2.4.2.6 Instrumentation

All instrument items shall be field calibrated and a calibration certificate shall be provided for each instrument.

Instrumentation shall be tested where applicable for;

- Full loop test using primary signal injection, i.e. temperature, pressure, flow etc.
- Check of the complete measurement/display from instrument to HMI for correct display including value and unit of measure and alarm points

The Contractor shall liaise with the Principal to carry out the above, and provide comprehensive calibration reports and testing check lists for each instrument.

13.2.5 Visual Inspections

Visual inspections shall include:

- Site survey to confirm installation at correct location and elevation in accordance with design
- Checking plant for conformity with standards and specifications, including materials, finishes, dimensions, connections, compaction
- Checking all fasteners, fittings, supports, alignments and clearances
- Checking for any evident damage, scratches, discolouration, corrosion, burrs, holes or other such defects
- Checking for any safety risks
- Checking that Plant is accessible and operable, and tasks as set out in the Operations and Maintenance plan can be carried out
- Required operating documentation is available on site
- All spares and tools provided and stored
- Any operating procedures, labels and other signage are in place
- Checking for proper function of drainage and erosion controls
- Any revegetation and permanent erosion control measures are in place.

13.2.6 Materials tests

All materials tests, including Manufacturer Data Records and site testing for locally acquired materials, shall be compiled and available.

13.2.7 Livening

The Inspections and Tests shall be deemed to have been completed when the Contractor has obtained from the Principal written verification that the said Inspections and Tests have been completed and passed in accordance with the Contract and that the Plant is ready for the commencement of the commissioning and livening.

The Contractor shall provide a detailed plan for livening equipment. This shall be provided in accordance with the network operator's standard practices, and the following requirements:

- Provided at least two weeks ahead of planned livening
- Planned date, time of commencement
- Expected date, time and duration for any outage
- List of necessary pre-conditions for livening, including pre-commissioning test results submitted
- Detailed steps and schedule for the livening process, including allocations of responsibilities, necessary checks and confirmations prior to each operation
- Required actions from the network operator
- Contingency plans

- Risk assessment appropriate to the task

Site notice of energisation requiring a minimum of 24 hours prior to energisation of new equipment. Contractor must follow site protocols, including issuance of required notice and confirmation of acceptance.

Checks during livening shall include operation of all essential services and system communications.

All checks during livening shall be accompanied by the necessary check sheets. Documentation shall be provided in accordance with the network operator's standard procedures.

13.2.8 Hand Over

Following successful livening, and the Plant operating as specified, and subject to completion of required training and (if relevant), the initial operations and maintenance period where the Contractor has responsibility for operation of the Plant, the Contractor may hand-over the Plant for operation to the Principal. Conduct of functional guarantee testing as required under the contract shall be undertaken by the Contractor in cooperation with the network operator. This may be undertaken prior to hand over, or the Principal will hand back operation of the Plant for the purpose of functional guarantee testing.

The Contractor shall provide to the Principal signed and dated reproducible copies of Reports, Red Lined As Built Drawings / Schedules and Inspection Test Sheets / Plans clearly showing the extent to which Inspections and Tests have been completed and the result of such inspection and testing. The Contractor must sign supplied check lists.

Handover documentation to include all operator and maintenance training, and higher level site engineer training on the equipment supplied.

14 Warranty requirements

In addition to the Contractors obligations during defect liability period (DLP)), the Contractor is also required to offer to assign all OEM warranties to the Principal. Novation of the warranty shall retain all warranty features available to the Contractor.

OEM warranties should apply for the maximum period offered by the OEM, and shall be a minimum of the following:

- SCADA Equipment 10 years
- PLC's 10 years (with 10 years software support)
- Other equipment: 2 years

All manufacturers for the above equipment manufacturer must hold current certification for compliance with ISO 9001, ISO 14001 and ISO 18001.

15 Remote commissioning

The Contractor must have procedures available to commission the GDMS (and any other specialty OEM hardware) without limitation on the availability of specialist personnel for physical travel. That is, in the event of border closures (irrespective of change of law) or unavailability of flights, or other such restriction, commissioning of specialist equipment shall be able to continue to schedule using remote commissioning processes.