REGISTERED
NATIONAL STANDARD

UNIT OF COMPETENCY

Title:	**Operate and maintain grid connected PV systems**[1]				
TQF Level:	4	**Credits:**	8	**Version:**	1
National standard code:	**NS123-04**				
Associated qualification (and code):	National Certificate in Sustainable Energy (Solar) Level 4				
Approval date:	10th June 2026	**Review date:**	10th June 2031		
Purpose:	This unit standard involves the operation and maintenance of PV systems (specifically grid-connected PV systems). Persons credited with this unit standard are able to: • Understand operation and components of a grid-connected PV system • Explain benefits and issues with integration of variable renewables into the grid • Plan safe maintenance of the grid connected PV system • Safely isolate the system for maintenance • Undertake service procedures and maintenance on the system • Troubleshoot grid connected PV systems and undertake basic repairs and replacement of equipment • Test and confirm before switching on the system • Maintain records of the system and provide documentation to the customer				

[1] Notes:

1) Due to safety issues inherent in working with electricity, all training and assessment activities must be in accordance with local industry and regulatory requirements;

2) This unit of competency has been adapted the EQAP micro qualification (micro credential *PPAG 301 Operator and Maintainer of PV systems (Grid-connected)*

Learning Outcome 1 (LO1)	Understand ***Occupational Health*** and ***Safety***
Performance standards	1.1 Carry out a Job Safety analysis (or risk assessment) with operation and maintenance of grid connected PV systems and develop skills on the following: • Identify job tasks • Identify hazards • Identify the risk class • Nominate risk control measures • Nominate a person responsible for carrying out each measure 1.2 Demonstrate knowledge on Occupational Safety & Health legislation and its application to the sustainable energy industry that may influence the operation and maintenance; 1.3 Apply defined safe working practices (particularly relating to the hazards of height, heavy weights, explosive gases, electric shock and burns); 1.4 Identify the PPE equipment for maintenance.
Learning Outcome 2 (LO2)	Understand grid connected PV system
Performance Standards	2.1 Explain the operating principle of grid connected PV systems; 2.2 Discuss typical components of a solar farm; **PV Arrays** 2.3 Identify relevant IEC module standards for certification, design qualification and safety approval; 2.4 Explain array configuration in terms of cells, modules, strings and array; 2.5 Describe operational characteristics of a solar module. **PV (Grid Connected) Inverters** 2.6 Identify relevant IEC certification and AS/NZS standards for inverter; 2.7 Explain the operating principles of different types of PV (grid-connect) inverters available; 2.8 Describe the Maximum Power Point Tracking feature of PV (grid connect) inverters;

	2.9 Explain inverter protection systems (active and passive protection), anti-islanding and common faults on an inverter; 2.10 Identify the specifications, maintenance requirements and controls for a range of commercially available PV (grid connect) inverters. **Balance of System** **Transformers, System Cabling, Disconnection and Protection** 2.11 Discuss balance of system components, distribution transformers, sub-station transformers, cabling, disconnectors, electrical protection, combiner boxers, metering and monitoring of PV systems through SCADA; 2.12 Explain voltage drop and its importance, apply formulas, discuss recommended voltage drop in a grid connected PV system; 2.13 Specify appropriate disconnection for all equipment/cables in a circuit for a grid connected PV system and confirm its rating; 2.14 Specify appropriate protection for all conductors in a circuit for a grid connected PV system and confirm protection device rating.
Learning Outcome 3 (LO3)	Understand integration of variable renewables into the grid
Performance standards	3.1 Explain the benefits of integration of solar PV into the grid; 3.2 Emphasize on reduction of energy imports and carbon emissions; 3.3 Discuss issues relevant to integrating variable renewables (solar and wind energy) into the grid including changes in power quality, utility dispatch capacity and voltage rise; 3.4 Suggest possible solutions to overcome issues due to variability in PV output including reactive power injection, geographical dispersion, solar forecasting and storage.
Learning Outcome 4 (LO4)	Carry out installation and replacement of system components
Performance standards	**PV Array**

	4.1 Demonstrate the components of mounting systems typical in large grid connected PV system, especially that on roof and ground mounted system; *(Range of demonstration should include but not restricted to assembling and dismantling these mounting systems. Also include specific installation requirements in a solar farm.)* **PV (Grid-connect) Inverter** 4.2 Demonstrate the correct positioning and sound mounting techniques. **General** 4.3 Demonstrate the replacement of components, cabling, metering, disconnectors and protection typical in a grid connected PV system; 4.4 Explain specific installation requirements in a solar farm.
Learning Outcome 5 (LO5)	Plan safe maintenance of the system
Performance standards	5.1 Describe all system components from those depicted in a system drawing; *(Range include but not restricted to Familiarize with grid connected PV system drawings typical in residential and commercial systems. Also include single line diagram/electrical schematics for a solar farm.)* 5.2 Discuss service and maintenance requirements on a grid connected PV system typical in residential, commercial and large solar farm. (Also emphasize on weed and vegetation control, erosion control, etc in a solar farm.); 5.3 Demonstrate planning of activities for maintenance in a grid connected PV system.; 5.4 Explain generic maintenance schedules of all system components with emphasis on periodic maintenance, preventative maintenance and condition-based maintenance; 5.5 State expected periods of maintenance for individual components including requirements for solar farms; 5.6 Identify tools and equipment required for maintaining and troubleshooting grid connected PV systems and demonstrate proficiency in their use.

Learning Outcome 6 (LO6)	Carry out safe isolation and maintenance procedures
Performance standards	6.1 Explain safe shut down procedure and general isolation procedure of the system for maintenance; 6.2 Demonstrate skills to confirm component specifications, cable size, ratings of disconnectors and protection equipment in the field; 6.3 Demonstrate skills on conducting a visual inspection within the system; 6.4 Identify the maintenance requirements from the visual inspection; 6.5 Develop procurement list include cost for service and/or maintenance; 6.6 Demonstrate maintenance procedures on individual PV modules, PV inverter, transformers and balance of system components; *(Range to include but not restricted to understanding error messages, alerts etc on inverter, knowing software updates, contacting support services and related issues.)* 6.7 Measure the voltage and current at PV inverter input and output; 6.8 Demonstrate a.c. electrical wiring termination, verification of proper connections, voltages, and polarity relationships; 6.9 Demonstrate the switching of the protection devices in a circuit and identify the rating, and type; 6.10 Explain labels on controls, disconnects and over current devices and wiring; 6.11 Perform safe isolation, carry out maintenance or service procedures in a grid connected PV system.
Learning Outcome 7 (LO7)	Troubleshoot grid connected PV systems
Performance standards	7.1 Discuss common faults in a grid connected PV system; 7.2 Specify suitable test equipment for diagnoses and testing within grid connected PV systems; 7.3 Diagnose and test the low power production in a solar farm;

	(Range to include but not restricted to the emphasis on IR imaging, I-V curve tracing, megohmmeter testing, short circuit current measurement along with the specification of tools, test conditions, test procedures and safety considerations for these testing.) 7.4 Discuss ground fault inverter troubleshooting (interpret error messages) and service; 7.5 Describe emergency shut-down procedure in times of natural disaster; 7.6 Measure system performance and operating parameters; 7.7 Identify performance and safety issues including plan safe isolation for servicing and maintenance; 7.8 Develop procurement list including cost for repair or replacement; 7.9 Perform safe isolation, repair or replace faulty components or faulty system upon troubleshooting.
Learning Outcome 8 (LO8)	Carry out ***testing*** and ***recording***
Performance standards	8.1 Conduct visual inspection of the entire system after maintenance and troubleshooting; 8.2 Resolve any deficiencies in materials or workmanship for the grid connected PV system; 8.3 Check system mechanical aspects for structural integrity and weather sealing if required; 8.4 Check electrical system for proper wiring practice, polarity, security of terminations, and grounding if required; 8.5 Conduct final testing and verification of complete functionality and performance of system, including start-up, shut-down and normal operation; 8.6 Compile and maintain records of system operation, performance, maintenance and results from troubleshooting faults; 8.7 State the system documentation that should be provided to the system owners after maintenance including updating of maintenance records and preparation of a report (if required).
Pre-requisites	• Electricians Qualification accredited Level 4 or equivalent OR

	• Passed in the NS118-04 Demonstrate electrical installation technology
Co-requisites	Concurrently attempt or completion of NS122-04 Determine sizing and installation of grid connected PV system
Underpinning skill and knowledge	The following knowledge and skills underpin this unit standard: **Knowledge:** 1. Safety requirements with solar PV systems 2. Knowledge of safe-handling techniques for moving, hoisting, lifting, etc. of heavy structures; 3. Knowledge of tools and equipment for solar system operation and maintenance; 4. Knowledge of basic functions and components of solar PV systems; 5. Basic knowledge of installing solar PV systems or replacing components **Skills** 6. Safe working principles and equipment handling skills 7. Preparing to install and test grid connected PV systems
Assessment requirements	**Methods of assessment:** A range of assessment methods should be used to assess students' knowledge and application of skills. These shall include but not restricted to the following: a) Direct observation of students performing certain tasks stated under context of assessment; b) Oral questions to test relevant skills and knowledge during observation (e.g., Interviews) c) Written assessment such as tutorial exercises on important topics. d) Practical assessment: Assessment of O&M skills to denote competency in grid connected PV system
Moderation arrangements	1. Training providers must have their own moderation system approved by TNQAB before accreditation is granted: a) Relevant internal moderation processes are documented; b) Assessment is planned for each unit, and moderation processes are integrated into such plan 2. External moderation is conducted by the National Qualifications unit of TNQAB for all unit components of national qualifications;

	a) Samples of assessed activities are submitted for moderation; b) Moderation (external) forms are available on request from the National Qualifications unit of TNQAB.
Resource requirements	1. A 3-5kW grid connected PV system including all major equipment (array, inverter) and all associated equipment (cabling, protection and isolating devices etc.). The system should reflect current industry practices in relation to operation and maintenance of grid connected PV systems 2. Site visits to at least **two solar farms** to gain knowledge on solar farm components and maintenance requirements 3. Worker's tools for undertaking installation, operation and maintenance • Insulated screw-drivers • Insulated pliers • Cordless drill set with drill bits • MC4 crimping tool • Torque wrench • Wire stripper • Measuring tape • Termination tools 4. Testing equipment • DC multimeter • Clamp meter (up to 20A d.c) • Insulation resistance tester • IV curve tracer • Compass, irradiance meter, inclinometer • IR camera 5. Personal Protection Equipment • Harness • Helmet • Safety glasses • Hand gloves 6. Recommended textbook: i. GSES, Grid-Connected PV Systems Design and Installation (9th ed.), Global Sustainable Energy Solutions Pty Ltd

	ii. Australia and New Zealand standards: AS/NZS 3000 iii. Relevant national or regional technical guidelines including the Pacific Power Association/ Sustainable Energy Industry Association of Pacific Islands regional guideline: Design of Grid Connected PV Systems, Installation of grid connected PV systems and Grid connected PV system - Operation and Maintenance Guideline iv. Relevant documentation comprising of manufacturer's technical information such as data sheets, installation manual and user guides.
Requirements to complete this unit	To demonstrate competence, the person studying this unit is: 1. Required to demonstrate all LOs to the expected standards of performance; 2. Required to attain an Achieved Grade (Competent) to fulfil the requirements of the Unit Standard. The person is required to be competent in the practical assessment to attain a pass grade in this unit. 3. Eligible to three (3) attempts in the practical assessment to achieve the required competency within 14 days of the first attempt. Failure to achieve the required competency level after three (3) attempts of the specific part of the final practical assessment will require the person studying this Unit to re-enrol for the same Unit.
Important notes and definitions	**Notes:** 1. All activities associated with this unit standard must comply with the requirements of national codes of practice, regulations and legislation for workplace health, safety, and environmental protection and any subsequent amendments. 2. Assessors must comply with Tonga national assessment and moderation requirements. 3. The delivery of all units of competencies must be in sequential order and ensure that the pre-requisites requirements are met. **Definitions:** 1. ***AS/NZS (Australia/New Zealand) standards*** dictate the mandatory safety, manufacturing, and operational rules

for electricity, appliances and installations. They ensure a baseline of protection against fire, electrocution, and damage to property across the country.

2. ***Grid connected PV systems (also known as on-grid)*** is a solar power setup that operates in direct parallel with your local utility electricity network.
3. ***Ground fault*** occurs when electrical current unintentionally leaves its designated circuit and takes a shortcut to the earth (ground). This usually happens due to damaged wire insulation, moisture intrusion, or faulty equipment, causing a live wire to touch a grounded metal casing, water, or a person.
4. ***Hazards*** refer to any situation or dangerous condition where contact with electrical systems or exposed conductors can cause harm, injury, or property damage.
5. ***IEC module standard*** usually refer to a hardware component or electronic assembly that complies with standards set by the Internation Electrotechnical Commission (IEC).
6. ***Occupational Health and Safety*** refers to the policies, procedures and standards designed to protect workers from electrical hazards like shocks, electrocution, fires and arc flashes. It mandates safe work practices, proper equipment maintenance, and the use of personal protective equipment (PPE).
7. ***PV (grid-connect) inverter*** is a device in a solar photovoltaic (PV) system that converts the direct current (DC) electricity generated by solar panels into usable alternating current (AC) electricity.
8. ***Risk control measures*** are safety protocols and engineering interventions designed to eliminate or minimize the dangers of electrical hazards, such as shocks, burns, arcs, and fires.
9. ***SCADA*** stands *for* ***Supervisory Control and Data Acquisition***. It functions as the central ***'nervous system'*** of the power grid. It is a combination of hardware and

	software that allows engineers to ***monitor, control and automate*** the generation, transmission, and distribution of electricity in real time. 10. ***System drawing*** is a standardized visual blueprint that maps out how electrical components connect and operate within a building, machine, or power grid. It uses universal symbols and lines to represent wires, switches, and devices to guide electricians safely through installation and troubleshooting.
Public comments on unit	Please contact TNQAB National Qualifications Unit (email EnquireNQ@tnqab.to or Telephone 28136) if you like to discuss or suggest changes to the details of this unit.