REGISTERED
NATIONAL STANDARD

UNIT OF COMPETENCY

Title:	**Operate and maintain off-grid PV systems (SHS and stand-alone PV systems)[1]**				
TQF Level:	4	**Credits:**	8	**Version:**	1
National standard code:	**NS121-04**				
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 maintenance and troubleshooting of solar based off-grid PV systems specifically, SHS and Stand-alone PV systems. Persons credited with this unit standard are able to: • Explain and identify essential components in the off-grid PV power system • Plan safe maintenance of the off-grid PV Power system • Produce a procurement list when required • Safely isolate the system for maintenance • Undertake service procedures and maintenance on the system • Troubleshoot an off-grid PV power 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 qualifications (micro credentials):

- *PPAOG 301 Maintainer of Off-Grid PV Power Systems (DC Load SHS)*
- *PPAOG 302 Maintainer of Off-Grid PV Power Systems (Stand-alone Solar Systems)*

Learning Outcome 1 (LO1)	Understand ***Occupational Health*** and ***Safety***
Performance standards	1.1 Apply local Occupational Safety and Health (OSH) regulations concerning worker and public safety; 1.2 Identify personal safety hazards, both electrical and physical, associated with off-grid PV power system (SHS and Stand-alone PV system) maintenance and troubleshooting, and implement preventative and remedial measures; 1.3 Identify environmental hazards associated with off-grid PV power system maintenance and troubleshooting, and implement preventative and remedial measures; 1.4 Identify the PPE equipment for maintenance.
Learning Outcome 2 (LO2)	Understand system components and demonstrating installation/replacement
Performance Standards	2.1 Explain configuration of a.c. and d.c coupled systems used in off-grid PV power systems. **PV Arrays** 2.2 Demonstrate the components of mounting systems typical in off-grid PV power system. **Battery Bank** 2.3 Discuss battery types typically used in off-grid PV power system (focus on vented, valve-release, sealed, liquid electrolyte, AGM, Gel, lead acid, NiCd, Lithium Ion) including reference to different cell voltages and how battery banks are configured; 2.4 Explain the factors and relevant manufacturers' data which relate to battery performance, mode of failure and expected life (viz DOD, discharge and charge currents and voltages, capacity at different discharge rates and temperatures, high and low ambient temperatures, over-discharge, over-charge, gassing, equalization, sulphation, stratification, plate corrosion, sludge shorting, electrolyte SG and volume); 2.5 Interpret commercially available battery specifications including warranty conditions; 2.6 Demonstrate battery bank replacement in an off-grid PV power system and explain factors which affect the longevity and performance of the battery bank such as

positioning the batteries so that they do not get adversely affected by the harsh environmental condition of the pacific islands (e.g. exposure to hot sun);

2.7 Demonstrate appropriate placement to optimize inter-cell connections and minimize excessive cable lengths;

2.8 Demonstrate the requirements for inlet and exhaust ventilation apertures for lead acid batteries;

Solar Controllers (Standard/MPPT Controller)

2.9 Demonstrate the replacement of solar charge controllers to:

- minimize cable lengths
- securely lock the solar controller to its supporting structure
- position the controller so that it is not adversely affected by the harsh environmental condition of the pacific islands
- be installed in accordance with manufacturers specifications
- provide a safe working environment and safe installation for the system owners

Battery Inverters/Hybrid Inverters

2.10 Explain the basic operating principles of battery inverters and a.c coupled interactive inverters include battery inverter and hybrid inverter components;

2.11 Elaborate on inverter specifications and features. (continuous, half-hour and surge power ratings and their temperature dependence, over and under voltage and frequency controls, harmonic distortion, stand-by power consumption, status-indicating, metering, data-logging and programming functions - and understand the use of shunts, audible noise, radio frequency interference, etc.);

2.12 Identify the factors which affect the efficiency and reliability of inverters, and their minimum location and housing requirements;

2.13 Compare the specifications, installation requirements and controls for a range of commercially available inverters;

2.14 Demonstrate the correct replacement and sound mounting techniques to:

- minimize cable lengths
- securely lock the battery inverter to its supporting structure
- ensure that the battery inverter is not adversely affected by the harsh environmental condition of the pacific islands.
- provide suitable airflow
- meet the installation requirements specified by the manufacturer
- provide a safe working environment and safe installation for the system owners

PV (Grid Connected) Inverters

2.15 Explain the operating principles of PV (grid-connect) inverters available. Describe the Maximum Power Point Tracking feature of PV (grid connect) inverters;

2.16 Identify the factors which affect the efficiency and reliability of inverters, and their minimum location and housing requirements;

2.17 Explain the effect of inverter efficiency on energy output of the system;

2.18 Identify the specifications, maintenance requirements and controls for a range of commercially available PV (grid connect) inverters;

2.19 Demonstrate the correct replacement and sound mounting techniques to:

- minimize cable lengths
- securely lock the PV inverter to its supporting structure
- ensure that the PV inverter is not adversely affected by the harsh environmental condition of the pacific islands.
- provide suitable airflow
- meet the installation requirements specified by the manufacturer

	• provide a safe working environment and safe installation for the system owners **General** 2.20 Demonstrate the replacement of all components, cabling and protection devices. (Typical in an off-grid PV power system ensuring minimized cable lengths between all components and installation of components in accordance with manufacturers specifications.)
Learning Outcome 3 (LO3)	Understand ***system cabling*** and ***system protection devices***
Performance Standards	3.1 Specify the technical ratings for a.c. and d.c cables in an off-grid PV power system; 3.2 Discuss the difference in installation standards and practices for a.c cables compared with d.c cables; 3.3 Confirm current carrying capacity for cables from tables or through calculations; 3.4 Demonstrate the replacement of cables and circuit protection devices in an off-grid PV Power system to minimize cable lengths between all components and install in accordance with manufacturer's specification; 3.5. Demonstrate the measurement of voltage/voltage drop in a conductor (a.c and d.c cables); 3.6 Demonstrate the measurement of current through a conductor (a.c and d.c cables); 3.7 Demonstrate the replacement of protection devices for all conductors in an off-grid PV power system; **Earthing (Grounding)** 3.8 Demonstrate replacement of earthing (grounding) systems as specified and required for off-grid PV power systems; 3.9 Demonstrate replacement of lightning protection systems as specified for the off-grid PV power system.
Learning Outcome 4 (LO4)	Plan safe maintenance of the system
Performance standards	4.1 Describe all system components from those depicted in a system drawing. (Familiarize with off-grid PV power system drawings.); 4.2 Discuss service and maintenance requirements of off-grid PV power systems;

	4.3 Demonstrate planning of activities for maintenance based on commonly occurring faults in an off-grid PV power system. (Explain generic maintenance schedules of all system components with emphasis on periodic maintenance and preventative maintenance. State expected periods of maintenance for individual components.); 4.4 Identify tools and equipment required for maintaining and troubleshooting off-grid PV power systems and demonstrate proficiency in their use.
Learning Outcome 5 (LO5)	Carry out safe isolation and maintenance procedure
Performance standards	5.1 Explain isolation procedure of the system for maintenance. (Also explain the correct sequence of switching on and switching off a system. Discuss precautionary measures with live a.c cables.); 5.2 Demonstrate skills to confirm component specifications, cable size, ratings of isolators and protection equipment in the field; 5.3 Demonstrate skills on conducting a walk-in survey of the site requiring maintenance and upon inspection. (Identify component failure symptoms, corrosion, loose wires and connections, etc. Identify maintenance requirements as identified and/or recommend service procedures for modules, arrays, batteries, controllers, safety systems, structural and weather sealing systems where applicable.); 5.4 Develop procurement list for service and/or maintenance; 5.5 Demonstrate maintenance procedures on individual off-grid PV system components including battery cells, solar controller, battery inverter/hybrid inverter and PV inverter; 5.6 Demonstrate the measurement of voltage at PV inverter input and output, individual battery cells, battery inverters inputs and outputs; 5.7 Demonstrate a.c. electrical wiring termination, verification of proper connections, voltages, and polarity relationships; 5.8 Verify continuity of circuits in the off-grid PV power system.
Learning Outcome 6 (LO6)	Troubleshoot off-grid PV systems

Performance standards	6.1 Discuss common faults in an off-grid PV power system; 6.2 Measure system performance and operating parameters; compare with specifications and expectations, and assess operating condition of system and equipment; 6.3 Perform diagnostic procedures and interpret results on faulty off-grid PV power systems; 6.4 Identify performance and safety issues, and plan safe isolation for servicing, replacement, etc; 6.5 Develop procurement list including cost for repair or replacement; 6.6 Perform safe isolation, service procedures and/or replacement of faulty components or faulty system.
Learning Outcome 7 (LO7)	Carry out ***testing*** and ***recording***
Performance standards	7.1 Conduct visual inspection on entire system after maintenance has been undertaken or equipment repair or replacement; 7.2 Check system mechanical aspects for structural integrity and weather sealing if required; 7.3 Check electrical system for proper wiring practice, polarity, security of terminations, and grounding if required; 7.4 Test and verify of complete functionality and performance of system, including start-up, shut-down and normal operation; 7.5 Compile and maintain records of system operation, performance, maintenance and results from troubleshooting faults; 7.6 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 NS118-04 Demonstrate electrical installation technology
Co-requisites	Concurrently attempt of NS120-04 Determine sizing and installation of off-grid PV systems (SHS and stand-alone PV system)

Underpinning skill and knowledge	The following knowledge and skills underpin this unit standard: **Knowledge:** 1. Safety of 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/operating solar PV systems 6. Knowledge of basic civil works involved in a solar PV set up. 7. Knowledge of the environmental and social impacts of solar PV system development. **Skills** 8. Safe working principles and equipment handling skills 9. Electrical wiring skills 10. Preparing to maintain off-grid 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 - One-on-one assessments and proving competency in maintaining and troubleshooting small-scale off-grid PV systems. Assessment of O&M skills to denote competency in off-grid PV system installations ***The student needs to be competent in the practical assessment.***
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. 4-8 sets solar home system including all major equipment (battery, array and controller); d.c lights and associated fittings and switches and all associated equipment (cabling, protection and isolating devices etc.). The system should reflect current industry practices in relation to installing/maintaining solar home systems 2. A small-scale off-grid PV power system including all major equipment (battery, array, inverter and controller) and all associated equipment (cabling, protection and isolating devices etc.). The system should reflect current industry practices in relation to installing/maintaining stand-alone PV systems. Both ac coupled and dc coupled configuration off-grid PV system need to be covered. 3. Worker's tools for undertaking installation • Insulated screw-drivers • Insulated pliers • Cordless drill set with drill bits • MC4 crimping tool • Torque wrench • Wire stripper • Measuring tape • Termination tools • Heat gun • Conduit bender • Rachet and socket set 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 • Eye protection • Apron • Helmet • Safety glasses • Hand gloves 6. Recommended textbook: i. GSES, Stand Alone Power Systems: Design and Installation (8th ed.), Global Sustainable Energy Solutions Pty Ltd ii. Relevant AS/NZS standards iii. Relevant national or regional technical guidelines including the Pacific Power Association/ Sustainable Energy Industry Association of Pacific Islands regional guideline: Design of Off-grid PV Systems and Installation of Off-grid PV systems 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 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. ***a.c*** stands for Alternating Current in electricity. The type of electrical current that periodically reverses direction, which is used to deliver power to homes and businesses. 2. ***AGM*** stands for ***Absorbent Glass Mat***. It refers to an advanced type of sealed lead-acid battery. ***3.*** ***Battery bank*** is a collection of two or more individual batteries connected together to act as a single, larger energy storage system. ***4.*** ***Battery inverters*** is a device that converts the Direct Current (DC) electricity stored in batteries into standard Alternating Current (AC) electricity used by most household appliances. ***5.*** ***d.c*** stands for ***Direct Current*** in electricity. This electrical current flows steadily in one direction, commonly found in batteries, solar cells and electronic devices. ***6.*** ***Earthing*** is a safety system that connects the metal parts of electrical appliances or installations directly to the earth via a low-resistance conductor. ***7.*** ***Hazards*** refer to any situation or dangerous condition where contact with electrical systems or exposed conductors can cause harm, injury, or property damage. ***8.*** ***Hybrid inverter*** is a device that combines a solar inverter and a battery inverter into a single unit. ***9.*** ***MPPT controller (Maximum Power Point Tracking controller)*** is a smart electronic device used in solar power systems. Its job is to extract the absolute maximum

possible power from solar panels and efficiently convert it into electricity to charge batteries.

10. ***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).
11. ***Off-grid PV systems*** is a standalone solar setup that generates and stores its own electricity without connecting to the public power grid. It relies entirely on solar panels to capture sunlight, batteries to store energy for use at night or on cloudy days, and an inverter to convert the power into usable.
12. ***PV arrays*** is a connected system of multiple solar panels that work together as a single power-generating unit. It captures sunlight and converts it into electricity, which is then routed through an inverter into usable power for homes, businesses, or the electrical grid.
13. ***PV inverter*** is a critical device in a solar power system. It converts the variable direct current (DC) electricity generated by solar panels into grid-compliant alternating (AC) electricity, which is the standard form of power used by household appliances and the electrical grid.
14. ***Solar controller*** is an electric device in an off-grid solar system that regulates the voltage and current coming from the solar panels.
15. ***System cabling*** refers to the organised design, installation, and management of electrical cables and hardware to distribute power and signals safely and efficiently throughout a structure.
16. ***System protection devices*** are safety components designed to detect abnormal conditions-like overloads, short circuits, or voltage spikes and automatically isolate the fault.

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.