

# REGISTERED NATIONAL STANDARD



## UNIT OF COMPETENCY

<b>Title:</b>	<b>Determine sizing and installation of off-grid PV systems (Hybrid systems)<sup>1</sup></b>		
<b>TQF Level:</b>	<b>4</b>	<b>Credits:</b>	<b>10</b>
		<b>Version:</b>	<b>1</b>
<b>National standard code:</b>	<b>NS124-04</b>		
<b>Associated qualification (and code):</b>	<b>National Certificate in Sustainable Energy (Solar) Level 4</b>		
<b>Approval date:</b>	<b>10<sup>th</sup> June 2026</b>	<b>Review date:</b>	<b>10<sup>th</sup> June 2031</b>
<b>Purpose:</b>	<p>This unit standard involves the sizing and installation of off-grid PV power systems specifically, a PV-Genset hybrid system. Persons credited with this unit standard are able to:</p> <ul style="list-style-type: none"> <li>• Undertake site assessment</li> <li>• Determine the site load requirements.</li> <li>• Select appropriate system configuration.</li> <li>• Size hybrid systems including: <ul style="list-style-type: none"> <li>○ the sizing of the PV array;</li> <li>○ the sizing of the battery bank</li> <li>○ the sizing/matching of the standard or MPPT controller(s) to the array;</li> <li>○ the sizing/matching of the PV (grid connect) inverter (s) to the array (a.c coupled system);</li> <li>○ the sizing of the battery inverter(s) and matching to the battery bank.</li> <li>○ the matching of the battery inverter(s) to the PV inverter(s) in an a.c. coupled system.</li> <li>○ the sizing of the fuel generator</li> <li>○ selecting the correct size cables and all associated protection devices and disconnectors</li> </ul> </li> <li>• Determine the system costs</li> <li>• Plan safe installation of hybrid systems;</li> <li>• Install hybrid systems in accordance with relevant standards and guidelines;</li> <li>• Test and commission hybrid systems including preparation of final documentation</li> </ul>		

<sup>1</sup> 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 103 Designer of Off-Grid PV Power Systems (Hybrid Power Systems)
- PPAOG 203 Installer of Off-Grid PV Power Systems (Hybrid Power Systems)

<b>Learning Outcome 1 (LO1)</b>	Understand <i>Occupational Health and Safety</i>
<b>Performance standards</b>	<p>1.1 Carry out a Job Safety analysis (or risk assessment) with Off-grid PV systems (Hybrid systems) and develop skills including:</p> <ul style="list-style-type: none"> <li>• Identify job tasks</li> <li>• Identify hazards</li> <li>• Identify the risk class</li> <li>• Nominate risk control measures</li> <li>• Nominate a person responsible for carrying out each measure</li> </ul> <p>1.2 Demonstrate knowledge on Occupational Safety &amp; Health legislation and its application to the sustainable energy industry that may influence the sizing and installation;</p> <p>1.3 Apply defined safe working practices (particularly relating to the hazards of height, heavy weights, explosive gases, electric shock and burns);</p> <p>1.4 Identify the PPE equipment for installation.</p>
<b>Learning Outcome 2 (LO2)</b>	Undertake <i>energy</i> and <i>site assessment</i> for a hybrid system
<b>Performance Standards</b>	<p>2.1 Analyze all the energy needs of the site and recommend what energy source) is best suited to the application;</p> <p>2.2 Determine the daily energy consumption of a site and if possible, for two seasons either summer/winter or wet/dry;</p> <p>2.3 Determine maximum and surge demand with respect to typical operation of the various loads identified at the site;</p> <p>2.4 Identify typical tools and equipment required for conducting site surveys for Hybrid installations, and demonstrate proficiency in their use;</p> <p>2.5 Establish suitable locations for the fuel generator(s) in relation to all the other system equipment and associated accessories and cabling;</p> <p>2.6 Diagram possible layouts and locations for Hybrid system equipment, including existing building or site features;</p> <p>2.7 Assess any site-specific safety hazards or other issues associated with installation of hybrid system.</p>
<b>Learning Outcome 3 (LO3)</b>	Understand system components and installation requirements
<b>Performance Standards</b>	<p><b>Fuel Generators</b></p> <p>3.1 Demonstrate understanding of different fuel generators available: diesel, petrol(gasoline), LPG and biofuels;</p> <p>3.2 Explain the operating principles of a diesel fuel internal combustion generator;</p>

	<p>3.3 Interpret the rating of generators (kVA compared with kW, measuring voltage and frequency stability against load);</p> <p>3.4 Explain that the cabling from the generator to the inverter/charger or charger exists at a dangerous voltage and if permanently wired must be carried out by a suitably qualified technician in accordance to the laws of the country;</p> <p>3.5 Discuss different starting systems for generators;</p> <p>3.6 Describe appropriate siting and segregating of generators (ignition of battery gases, heat, noise, fumes and fuel storage);</p> <p>3.7 Discuss commercially available package generator sets and exhaust, silencing and fuel tank options;</p> <p>3.8 Explain the multi-phase alternator with knowledge of wiring configuration for 3 phases to single phase conversion and the de-rating of outputs due to the reconfiguration;</p> <p>3.9 Equate generator efficiency to fuel consumption and discuss generator efficiency as related to series and parallel inverter configurations;</p> <p>3.10 Explain interlocking between generation sources to ensure PV not feeding power to the genset (reverse power).</p> <p><b>Remote Monitoring/Data Logging</b></p> <p>3.11 Explain the operating principles of data logging equipment;</p> <p>3.12 Develop knowledge on calibrating a data logger;</p> <p>3.13 Explain the use of data transfer interface devices;</p> <p>3.14 Explain the effect on the accuracy of data when collected over different sampling periods and the ease with which data is processed at different sampling rates;</p> <p>3.15 Discuss commercially available software used for presenting tabular and graphical data, e.g. spreadsheets.</p>
<b>Learning Outcome 4 (LO4)</b>	Undertake system design
<b>Performance standards</b>	<p>4.1 Demonstrate knowledge of a.c. and d.c. coupled systems (with fuel generators);</p> <p>4.2 For d.c. coupled systems demonstrate knowledge of series, switched and parallel generator systems;</p> <p>4.3 Calculate the quantity of daily load which is met by each of the energy sources for d.c or a.c coupled systems or combined a.c and d.c. coupled system such as:</p> <ul style="list-style-type: none"> <li>• Fuel generator directly</li> <li>• PV array directly</li> </ul>

- Battery being charged by fuel generator
- Battery being charged by PV array

### **PV Array**

4.4 Calculate the array size required to meet loads either directly from the PV array or to charge batteries. (based on the type of system configuration).

### **Battery Bank**

4.5 Determine required battery bank capacity to meet the energy consumption being supplied by the battery bank for hybrid systems. (Allowing for energy being supplied via the battery bank and not directly by the fuel genset.);

### **Battery Inverter/Hybrid Inverter**

- 4.6 Match the battery charging capability of the battery inverter to the battery bank and also the selected generator;
- 4.7 Determine required battery inverter specifications for the hybrid system considering appropriate over-sizing and future considerations.

### **Standard Solar Controllers**

- 4.8 Match solar controller's specifications with system parameters (voltage and current of the array);
- 4.9 Select an appropriate controller / regulator for the system.

### **MPPT Solar Controller**

- 4.10 Match MPPT specifications with system parameters (voltage, current and power of the array);
- 4.11 Select an appropriate MPPT for the system.

### **PV (Grid Connect) Inverters**

- 4.12 Match PV (Grid Connect) Inverter specifications with system parameters (voltage, current and power of the array);
- 4.13 Select an appropriate PV (Grid Connect) Inverter for the system.

	<p><b>Fuel Generators</b></p> <p>4.14 Calculate the apparent power (VA) and surge power (VA) required for the generator;</p> <p><b>Balance of Systems</b> <b>System Cabling and Circuit Protection</b></p> <p>4.15 Calculate voltage drop for all conductors in a Hybrid system;</p> <p>4.16 Determine minimum cable size based on current carrying capacity and voltage drop;</p> <p>4.17 Specify appropriate protection for all conductors in a circuit for a Hybrid system and calculate protection device rating;</p> <p>4.18 Calculate the system cost.</p>
<b>Learning Outcome 5 (LO5)</b>	Carry out installation procedures of system components
<b>Performance standards</b>	<p><b>Fuel Generator</b></p> <p>5.1 Demonstrate the correct positioning and sound mounting techniques to:</p> <ul style="list-style-type: none"> <li>• securely lock the generator plant to its supporting structure</li> <li>• provide suitable sound attenuation</li> <li>• provide vibration isolation, exhaust extraction and cooling ventilation to comply with manufacturer’s specification.</li> <li>• allow adequate access to all plant components for maintenance and fault finding</li> </ul> <p>5.2 Explain the suitable location of fuel storage tanks and fuel lines to comply with relevant standards.</p> <p><b>Balance of System Components</b> <b>General</b></p> <p>5.3 Demonstrate the positioning and fixing of all system components of a hybrid power system in place to:</p> <ul style="list-style-type: none"> <li>• minimize cable lengths between all components</li> <li>• be installed in accordance with manufacturer’s specifications</li> <li>• provide a safe working environment and safe installation for the system owners</li> </ul>

	<p>5.4 Layout, secure system components in position and:</p> <ul style="list-style-type: none"> <li>• Demonstrate diagrammatically</li> <li>• Understand the reasons for optimal system component layout</li> <li>• Demonstrate the use of appropriate fixing systems to secure system components in place</li> </ul> <p><b>Remote Monitoring/COMMS/ Data Logging</b></p> <p>5.5 Demonstrate the positioning and fixing of all remote monitoring, communications and data logging equipment.</p>
<b>Learning Outcome 6 (LO6)</b>	Understand system cabling and system protection devices
<b>Performance standards</b>	<p>6.1 Identify acceptable/permissible voltage drop in all the circuits for a hybrid system;</p> <p>6.2 Demonstrate the installation of protection devices for conductors in the hybrid power system.</p> <p><b>Cabling for Multiple Buildings and/or Village</b></p> <p>6.3 Demonstrate the installation of electrical transmission configuration, such as underground or overhead for the a.c. cables;</p> <p>6.4 Demonstrate the installation of protection requirements for the different buildings and the interconnection cabling to the buildings.</p> <p><b>Earthing (Grounding)</b></p> <p>6.5 Install earthing (grounding) systems as specified and required for hybrid power systems;</p> <p>6.6 Install lightning protection systems as required.</p>
<b>Learning Outcome 7 (LO7)</b>	Carry out final system installation
<b>Performance standards</b>	<p>7.1 Demonstrate safe techniques for laying and securing cables in place in a hybrid power system;</p> <p>7.2 Demonstrate the use of appropriate physical protection for installed cables;</p> <p>7.3 Complete final assembly, structural attachment, and weather sealing of array to building or other support mechanism of the hybrid power system;</p>

	<p>7.4 Install and provide required labels on controls, disconnects and over current devices for the hybrid power system;</p> <p>7.5 Label, install, and terminate electrical wiring, verify proper connections, voltages, and polarity relationships;</p> <p>7.6 Install signage requirements that meet relevant local requirements, standards and industry best practices as specified by the designer and or supervisor;</p> <p>7.7 Verify continuity in circuits.</p>
<b>Learning Outcome 8 (LO8)</b>	Carry out <i>testing</i> and <i>commissioning</i>
<b>Performance standards</b>	<p>8.1 Conduct visual inspection of entire installation, identifying and resolving any deficiencies in materials or workmanship for the hybrid power system;</p> <p>8.2 Check system mechanical installation for structural integrity and weather sealing as required;</p> <p>8.3 Check electrical installation for proper wiring practice, polarity, security of terminations, and grounding when necessary;</p> <p>8.4 Activate system and verify overall system functionality and performance, compare with expectations;</p> <p>8.5 Demonstrate correct sequence for connecting and disconnecting the system and equipment from all sources;</p> <p>8.6 Identify and verify all markings and labels for system and equipment as required;</p> <p>8.7 Explain all safety issues associated with operation and maintenance of hybrid system;</p> <p>8.8 Explain complete documentation package for the system and equipment to owner/operator.</p>
<b>Pre-requisites</b>	<ul style="list-style-type: none"> <li>• Pass NS120-04 Determine sizing and installation of off-grid PV system (SHS and stand-alone PV system)</li> </ul>
<b>Co-requisites</b>	N/A
<b>Underpinning skill and knowledge</b>	<p>The following knowledge and skills underpin this unit standard:</p> <p><b>Knowledge:</b></p> <ol style="list-style-type: none"> <li>1. Safety of solar PV systems</li> <li>2. Knowledge of safe-handling techniques for moving, hoisting, lifting, etc. of heavy structures;</li> <li>3. Knowledge of tools and equipment for solar installation;</li> <li>4. Knowledge of basic functions and components of solar PV systems;</li> <li>5. Basic knowledge of installing and operating solar PV systems</li> <li>6. Knowledge of basic civil works involved in a solar PV set up.</li> </ol>

	<p>7. Knowledge of the environmental and social impacts of solar PV system development.</p> <p><b>Skills</b></p> <p>8. Safe working principles and equipment handling skills</p> <p>9. Preparing to install off-grid PV systems</p> <p>10. Installing off-grid PV systems</p>
<p><b>Assessment requirements</b></p>	<p><u><b>Methods of assessment:</b></u></p> <p>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:</p> <ul style="list-style-type: none"> <li>a) Direct observation of students performing certain tasks stated under context of assessment;</li> <li>b) Oral questions to test relevant skills and knowledge during observation (e.g., Interviews)</li> <li>c) Written assessment such as: <ul style="list-style-type: none"> <li>i) Tutorial exercises on important topics in preparation for the final examination</li> <li>ii) Design task for sizing an Off-grid Hybrid PV system to denote competency in sizing components</li> <li>iii) Final examination</li> </ul> </li> <li>d) Practical assessment: <p>Assessment of install skills to denote competency in off-grid PV hybrid system installations</p> </li> </ul> <p><i>The student needs to be competent in the final exam and the practical assessment to be classified as "competent" overall for the unit.</i></p>
<p><b>Moderation arrangements</b></p>	<ul style="list-style-type: none"> <li>1. Training providers must have their own moderation system approved by TNQAB before accreditation is granted: <ul style="list-style-type: none"> <li>a. Relevant internal moderation processes are documented</li> <li>b. Assessment is planned for each unit, and moderation processes are integrated into such plan</li> </ul> </li> <li>2. External moderation is conducted by the National Qualifications unit of TNQAB for all unit components of national qualifications: <ul style="list-style-type: none"> <li>a. Samples of assessed activities are submitted for moderation;</li> <li>b. Moderation (external) forms are available on request from the National Qualifications unit of TNQAB.</li> </ul> </li> </ul>

## Resource requirements

1. A PV/Genset hybrid system including all major equipment (battery, array, PV inverter and or solar controller, battery inverter and generator) and all associated equipment (cabling, protection and isolating devices etc.). The system should reflect current industry practices in relation to installing and setting up hybrid systems. Both ac coupled and dc coupled configuration off-grid hybrid system need to be covered.
2. 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
  - Ratchet and socket set
3. Testing equipment
  - DC multimeter
  - Clamp meter (up to 20A d.c )
  - Insulation resistance tester
  - IV curve tracer
  - Compass, irradiance meter, inclinometer
  - IR camera
4. Personal Protection Equipment
  - Harness
  - Eye protection
  - Apron
  - Helmet
  - Safety glasses
  - Hand gloves
5. Recommended textbook:
  - i. GSES, Stand Alone Power Systems: Design and Installation (8th ed.), Global Sustainable Energy Solutions Pty Ltd

	<ul style="list-style-type: none"> <li>ii. Australia and New Zealand standards: AS/NZS 3000</li> <li>iii. Relevant national or regional technical guidelines including the Pacific Power Association/ Sustainable Energy Industry Association of Pacific Islands regional guideline: Hybrid Power Systems (PV and Fuelled Generator) – System Design and Installation Guidelines</li> <li>iv. Relevant documentation comprising of manufacturer’s technical information such as data sheets, installation manual and user guides.</li> </ul>
<p><b>Requirements to complete this unit</b></p>	<p>To demonstrate competence, the person studying this unit is:</p> <ol style="list-style-type: none"> <li>1. Required to demonstrate all LOs to the expected standards of performance;</li> <li>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 final exam and practical assessment to attain a pass grade in this unit.</li> <li>3. Eligible to three (3) attempts in the final exam/practical assessment to achieve the required competency within 14 days of the first attempt.</li> </ol> <p>Failure to achieve the required competency level after three (3) attempts of the exam or specific part of the assessment will require the person studying this Unit to re-enrol for the same Unit.</p>
<p><b>Important notes and definitions</b></p>	<p><b><u>Notes:</u></b></p> <ol style="list-style-type: none"> <li>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.</li> <li>2. Assessors must comply with Tonga national assessment and moderation requirements.</li> <li>3. The delivery of all units of competencies must be in sequential order and ensure that the pre-requisites requirements are met.</li> </ol> <p><b><u>Definitions:</u></b></p> <ol style="list-style-type: none"> <li>1. <i>a.c</i> 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.</li> </ol>

2. **Battery bank** is a collection of two or more individual batteries connected together to act as a single, larger energy storage system.
3. **Calibrating a data logger** means comparing its measurements against a known, highly accurate reference standard to detect and correct any inaccuracies. Over time, electronic components naturally 'drift', so calibration ensures the logger's recorded voltage, current, or energy readings remain precise and trustworthy.
4. **Data logging** is the process of using specialized devices to continuously monitor and record electrical parameters such as voltage, current, and power consumption over specific period.
5. **Data transfer interface device** is hardware that connects an electrical apparatus to a communication network.
6. **d.c coupled systems** refers to an energy setup (like solar and battery storage) where components share a single DC (Direct Current) bus before passing through an inverter.
7. **Earthing (or grounding)** is a crucial safety system that connects the metal parts of electrical appliances and your home's electrical panel directly to the earth.
8. **Hazards** refer to any situation or dangerous condition where contact with electrical systems or exposed conductors can cause harm, injury, or property damage.
9. **Installation** is a connected assembly of electrical equipment and wiring designed to safely and efficiently distribute electricity throughout a structure.
10. **kVA** stands for kilovolt-amperes. It is a unit of measurement used to express *apparent power* in an electrical system.
11. **kW** stands for kilowatt. It measures *power* – the exact *rate* at which an appliance or system uses (or generates) electricity at any given moment.
12. **LPG (Liquified Petroleum Gas)** is a highly portable, combustible hydrocarbon fuel (usually propane or butane) used to generate power or as an alternative to grid electricity for household appliances.
13. **MPPT (Maximum Power Point Tracker)** is an electronic technique and algorithm used in electrical systems – most

	<p>commonly in solar power setups – to extract the maximum possible energy from a power source as environmental conditions change.</p> <p>14. <i>Occupational Health and Safety</i> 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).</p> <p>15. <i>Off-grid PV systems</i> 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.</p> <p>16. <i>Standard solar controller (or solar charge controller)</i> is an electronic device that acts as the ‘brain’ of an off-grid or hybrid solar system.</p> <p>17. <i>System cost</i> refers to the total expenses required to build, maintain, and operate the broader power infrastructure beyond the physical power plant itself.</p>
<p><b>Public comments on unit</b></p>	<p>Please contact TNQAB National Qualifications Unit (email <a href="mailto:EnquireNQ@tnqab.to">EnquireNQ@tnqab.to</a> or Telephone 28136) if you like to discuss or suggest changes to the details of this unit.</p>