REGISTERED NATIONAL STANDARD

UNIT OF COMPETENCY

Title:	**Determine sizing and installation of grid connected PV systems**[1]				
TQF Level:	4	**Credits:**	10	**Version:**	1
National standard code:	**NS122-04**				
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 sizing and installation of grid connected PV systems.
	Learners credited with this unit standard are able to:
	• Undertake site assessments
	• Determine the available solar resource
	• Size grid connected PV systems including:
	  ○ determining the power rating of the PV array to meet design requirements
	  ○ the matching of the PV array and inverter (s);
	  ○ selecting the correct size cables and all associated protection and disconnectors
	• Determine the energy yield from a grid connected PV system.
	• Plan safe installation of grid connected PV systems;
	• Install grid connected PV systems in accordance with relevant standards and guidelines;
	• Test and commission grid connected PV systems				

[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):

- *PPAGC 100 Designer of Grid Connected PV Systems*
- *PPAGC 200 Installer of Grid Connected PV Systems*

Learning Outcome 1 (LO1)	Understand ***Occupational Health*** and ***Safety***
Performance standards	1.1 Carry out a Job Safety analysis (or risk assessment) with grid connected PV systems and develop skills including: • 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 design and installation; 1.3 Apply defined safe working practices (particularly relating to the hazards of height, heavy weights, explosive gases, electric shock and burns) and identify personal protective equipment for usage; 1.4 Identify the PPE equipment for installation.
Learning Outcome 2 (LO2)	Understand energy concepts and Solar energy fundamentals
Performance Standards	**Energy Concepts** 2.1 Demonstrate knowledge of correct units for energy and power; 2.2 Demonstrate conversion from one unit to another including percentage conversions; 2.3 Demonstrate the use of the prefixes; kilo, mega, giga, etc. when converting units; 2.4 Identify the power rating of electrical appliances; 2.5 Calculate the effective energy consumption from power rating and operating duration (duty cycle). **Solar Energy Fundamentals** 2.6 Describe the global energy situation and the need for renewable energy technologies; 2.7 Explain solar energy and its application; *(Range of solar energy application included but not restricted to solar PV and solar thermal generation, use in solar water pumping, solar water heaters, use in small solar appliances, marine and satellite applications, etc.)* 2.8 Explain different types of solar PV systems;

	(Range of different types of solar PV systems may include but not restricted to grid connected PV systems, off-grid PV systems including hybrids, grid connected PV system with battery storage, etc.)
Learning Outcome 3 (LO3)	Determine *Solar* resources
Performance standards	3.1. Access and interpret solar radiation data available from different sources and equipment; 3.2 Demonstrate understanding on the sun's position and the orientation and tilt of a solar module for optimum output; 3.3 Define the term irradiance and irradiation ('peak sun hours'); 3.4 Quantify the irradiation to array orientation, inclination and time of the year; 3.5 Quantify the impact of shading on the irradiation for a sample site.
Learning Outcome 4 (LO4)	Undertake a site visit
Performance standards	4..1 Survey the customer to determine the reasons for installing a grid connect PV System and enquire on the expected PV output requirements; 4.2 Demonstrate understanding of local utility energy metering and interpret billing notices; 4.3 Carry out the site visit plan and documentation; 4.4 Perform site assessment: • The available solar resource for the array orientation and inclination; • The available roof space and expected array size; • The location of all the system equipment including solar array, inverter, cabling and balance of system.
Learning Outcome 5 (LO5)	Understand system components
Performance standards	**PV Arrays** 5.1 Understand the basic operation of silicone-based PV cells. (Gain knowledge on various other common types of solar cell technology available including thin-film, multi-junction, etc); 5.2 Compare the following PV cell technology and the different manufacturers' data viz: • monocrystalline • polycrystalline

- amorphous (thin film)
- PERC (Passivated Emitter and Rear Cell)
- TOPCon (Tunnel Oxide Passivated Contact)
- Heterojunction Technology (HJT)
- Multi-junction

5.3 Interpret the technical specifications and output characteristics of photovoltaic modules. (understand the terms Isc, Voc, Imp, Vmp, Pmax along with the temperature coefficients);

5.4 Define the factors which influence the output characteristics of photovoltaic modules (irradiance, temperature, dirt, manufactures tolerance and age);

5.5 Assess a site in relation to information from published wind data, and the suitability of the array frame and mounting techniques to meet wind loading requirements;

5.6 Demonstrate series and parallel circuits on PV modules;

5.7 Demonstrate the effect on array output (current, voltage and power) of connecting modules in series and parallel configurations;

5.8 Explain the effects of using dissimilar modules in an array;

5.9 Determine available array roof space and module spacing;

5.10 Demonstrate the use of blocking and bypass diodes with the different types of PV modules including the effect of diodes on array output.

Inverters

5.11 Demonstrate knowledge on the operating principles of different types of grid-interactive inverters available;

5.12 Identify required inverter specifications for PV array matching;

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

5.14 Demonstrate an understanding of the Maximum Power Point Tracking feature of grid connect inverters;

5.15 Demonstrate a working knowledge of inverter specifications and features;

(Range include but not restricted to over and under voltage and frequency controls, harmonic distortion, stand-by power

	consumption, status-indicating, metering, data-logging and programming functions - and understand the problems associated with audible noise, radio frequency interference, etc.) 5.16 Explain interlocking feature between generation sources to ensure PV not feeding power to the genset (reverse power) where generator systems are present or when backup generators come online and the controls required. **Balance of System Components** **System Cabling, Disconnection, Circuit Protection and Metering** 5.17 Develop understanding and classify string, sub-array and array cables positioning; 5.18 Identify relevant disconnection devices and circuit protection devices to be used on grid connected PV systems and their positioning according to AS/NZS standards; 5.19 Specify the types of metering relevant on grid connected PV systems and the positioning of meters. These may include: • measuring all the energy from the system • measuring only the energy that is supplied to the grid • a combination of the two.
Learning Outcome 6 (LO6)	Sizing a grid connected PV system
Performance standards	6.1 Specify all relevant AS/NZS standards, SEIAPI technical guidelines and local electrical utility requirements for design and installation; **Array – Inverter Matching** 6.2 Demonstrate with examples or calculations skills on matching array and inverter voltage, array and inverter current, and array and inverter power rating. **Balance of System Components** **System Cabling, Disconnection, Circuit Protection and Metering**

	6.3 Specify appropriate voltage and current ratings for disconnection devices, cables and equipment according to the AS/NZS wiring standards and SEIAPI Technical guidelines; 6.4 Demonstrate calculation of voltage drop for all cables (DC and AC) in the system and explain the implications of excessive voltage drop on system performance; 6.5 Specify cable sizing for string, sub-array and array conductor based on current carrying capability and voltage drop; 6.6 Specify appropriate protection for all conductors in a circuit and their current ratings according to the AS/NZS wiring standards; 6.7 Specify appropriate interconnection to the utility grid. **Overall System Performance** 6.8 Calculate overall system efficiency, specific yield and performance ratio for a system; 6.9 Specify the system documentation that should be provided to the system owners which should include drawings, commissioning results, start-up procedure, shut down procedure, maintenance information, warranty etc.
Learning Outcome 7 (LO7)	Carry out final system installation
Performance standards	7.1 Identify and describe all system components from those depicted in a system drawing or single line diagram; 7.2 Prepare a procurement list of all system components from a system drawing or single line diagram; 7.3 Identify actual location for all equipment to be installed on site; 7.4 Verify that the array operating voltage range is within acceptable operating limits for grid connect inverters; 7.5 Demonstrate sound mounting design and techniques for attaching modules to the array frame and the array frame to its supporting structure with emphasis on the following: • use of appropriate bolts or screws, including gauge, penetration, etc. • fixing of external timber or metal battens to the roof sub frame

	• weather sealing of array to building or other support mechanism e.g. use of dectite 7.6 Demonstrate sound mounting design and techniques for ground mounted PV systems; 7.7 Demonstrate the positioning and installation of all system components in place to: • minimize cable lengths between all components • provide an ergonomic system layout • provide a safe working environment and safe installation for the system owners 7.8 Install cabling between modules, inverter and switchboard; 7.9 Install earthing (grounding) conductor, grounding lug, WEEB washer or similar and lightning or surge protection devices; 7.10 Complete final assembly, structural attachment, and weather sealing of array to building or other support mechanism; 7.11 Install and provide required labels on inverters, controls, disconnects and overcurrent devices, surge suppression and earthing (grounding) equipment, junction boxes and enclosures, conduit, and other electrical hardware; 7.12Label, install, and terminate electrical wiring, verify proper connections, voltages, and phase/polarity relationships; 7.13Verify continuity and measure impedance of earthing (grounding) system; 7.14 Program, adjust, and/or configure inverters and controls for desired set points and operating modes.
Learning Outcome 8 (LO8)	Carry out ***testing*** and ***commissioning***
Performance standards	8.1 Visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship; 8.2 Demonstrate skills on checking system mechanical installation for structural integrity and weather sealing; 8.3 Demonstrate the use of multimeters, dc clamp meters, insulation resistance testers and other test equipment to undertake short circuit current test, insulation resistance test, polarity test, etc;

	8.4 Check electrical installation for proper wiring practice, polarity, earthing(grounding), and integrity of terminations; 8.5 Activate system and verify overall system functionality and performance; compare with expectations; 8.6 Demonstrate procedures for step by step connecting and disconnecting the system and equipment from all sources; 8.7 Identify and verify all required markings and labels for the system and equipment; 8.8 State what documentation is required to be provided to the PV system owner/operator by the installer.
Pre-requisites	• Electricians Qualification accredited Level 4 or equivalent OR • Passed in the NS117-04 Develop knowledge on Electrical Principles PLUS • Passed in the NS118-04 Demonstrate electrical installation technology
Co-requisites	N/A
Underpinning skill and knowledge	The following knowledge and skills underpin this unit standard: **Knowledge:** 1. Basic safety knowledge 2. Knowledge of safe-handling techniques for moving, hoisting, lifting, etc. of heavy structures; 3. Knowledge of tools and equipment for solar installation; 4. Knowledge of electrical principles and electrical installation technology **Skills** 5. Safe working principles and equipment handling skills 6. Basics of electrical wiring
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: i) Tutorial exercises on important topics in preparation for the final examination ii) Design task for sizing a small-scale grid connected PV system to denote competency in sizing components iii) Final examination d) Practical assessment: Assessment of install skills to denote competency in grid connected PV system installations ***The student needs to be competent in the final exam and the practical assessment to be classified as "Competent" overall for the unit.***
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 installing and setting up grid connected PV systems 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 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 • Helmet • Safety glasses • Hand gloves 5. Recommended textbook: i. GSES, Grid-Connected PV Systems Design and Installation (9th ed.), Global Sustainable Energy Solutions Pty Ltd ii. Relevant Australia and New Zealand standards: AS/NZS 3000 (AS/NZS 5033, AS/NZS 4777) 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 and Installation of grid connected 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 final exam and practical assessment to attain a pass grade in this unit. 3. Eligible to three (3) attempts in the final exam/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 exam or 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.*** ***Array*** refers to an interconnected group of individual electrical devices – most commonly solar panels. ***2.*** ***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. ***3.*** ***Circuit protection*** refers to the safety mechanisms built into electrical systems to prevent damage caused by excessive current, short circuits, or voltage surges. ***4.*** ***Disconnection*** means the physical interruption or intentional stopping of the flow of electrical power to a property, circuit, or appliance. ***5.*** ***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.

6. ***Hazards*** refer to any situation or dangerous condition where contact with electrical systems or exposed conductors can cause harm, injury, or property damage.
7. ***Irradiance*** refers to the intensity of sunlight hitting a surface at any given moment. It measures the amount of radiant solar power falling on a unit area.
8. ***Irradiation*** refers to the exposure of an object or material to high-energy radiation.
9. ***Installation*** refers to the system of connected electrical equipment, wiring, and devices used to safely distribute and utilize electricity within a building or property.
10. ***Metering*** refers to the process of measuring and recording the amount of electrical energy consumed by a residential, commercial, or industrial property.
11. ***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).
12. ***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.
13. ***Polarity*** refers to the directional orientation of electrical charge within a circuit, defining the positive and negative poles. It determines which direction the current flows.
14. ***Power rating*** is the maximum amount of electrical power a device or component can safely handle, use, or deliver.
15. ***PV arrays*** is a linked collection of multiple solar panels (modules) designed to capture sunlight and generate electricity.
16. ***PV systems*** is a setup that converts sunlight directly into usable electrical energy using solar panels.

	17. ***Solar energy*** means converting the sun's radiation into usable electrical power. 18. ***Solar energy fundamentals*** refer to the conversion of sunlight into usable electrical power. 19. ***Solar resources*** refer to the availability and intensity of sunlight (solar radiation) at a specific geographic location. It is the raw, natural fuel used to generate solar power. 20. ***Solar thermal generation*** is the process of using the sun's heat (not its light) to produce electricity.
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.