REGISTERED
NATIONAL STANDARD

UNIT OF COMPETENCY

Title:	**Determine** sizing and installation of grid connected PV system with battery storage[1]				
TQF Level:	4	**Credits:**	8	**Version:**	1
National standard code:	**NS126-04**				
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 system with battery storage (GCPVwBS). Learners credited with this unit standard are able to: • Identify hazards associated with GCPVwBS and implement appropriate risk control measures • Explain battery terminologies such as BESS and battery systems and functions desired such as grid back-up, minimise PV export, grid as back up, tariff arbitrage, etc. Also explain typical configurations. • Size GCPVwBS to meet system and performance requirements including: - Specifying appropriate configuration - Sizing of inverter (s) - Sizing of battery storage systems - Sizing of PV array • Determine size of cables and ratings of protection and disconnection devices • Plan safe installation of GCPVwBS • Carry out installation of GCPVwBS • Test and Commission GCPVwBS • Maintain and troubleshoot GCPVwBS • Document installation and maintenance procedures				

[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):

- *PPAGB 501 Designer of Grid Connected PV System with batteries*
- *PPAGB 402 Installer of Grid Connected PV System with batteries*

Learning Outcome 1 (LO1)	Understand ***Occupational Health*** and ***Safety***
Performance standards	1.1 Apply Occupational Safety and Health legislations concerning worker and public safety; 1.2 Apply safety procedures concerning battery storage installations as specified by the designer and or supervisor; 1.3. Carry out a Job Safety Analysis on grid connected PV system with battery storage with emphasis 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 1.4 Demonstrate safe working practices (particularly relating to the hazards of heavy weights, explosive gases, electric shock and burns) for grid connected PV systems with battery storage; 1.5 Identify environmental hazards associated with grid connected PV system with battery storage installations, and implement preventative and remedial measures; 1.6 Identify the PPE equipment for installation.
Learning Outcome 2 (LO2)	Understand ***battery energy storage system*** (BESS) functions and components
Performance Standards	2.1 Specify different system functions that are commonly desired in system design in the country. (To meet back-up requirements, zero-export or other essential requirements.); 2.2 Specify common system configurations used for new grid connected PV systems with batteries and common system; configurations for the use of existing grid connected PV systems as grid-connected PV system with battery storage; 2.3 Explain the system components used in a grid connected PV system with battery storage. **Inverters** 2.4 Specify the differences between grid-connect battery inverter, PV grid connect inverter, grid-connect battery inverters, battery inverter and PV/Battery grid connect inverter or hybrid inverter; 2.5 Identify the factors which affect the efficiency and reliability of PV inverters and battery grid connect inverters, and their minimum location and housing requirements;

	2.6 Compare the specifications, installation requirements and controls for a range of commercially available PV grid connect inverters and grid-connected battery inverters; 2.7 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. **Battery Bank** 2.8 Explain different battery technologies, internal battery design variations and characteristics for different system requirements. (including reliability, safety, convenience, life and cost (vented, valve-release, sealed, liquid electrolyte, AGM, Gel, Lithium ion, 2 volts cells, 4–24-volt batteries, etc); 2.9 Explain the factors and relevant manufacturers' data which relate to battery performance, expected life (viz depth of discharge (DOD), and mode of failure. (For example: discharge and charge currents and voltages, capacity at different discharge rates and temperatures, effect of high and low ambient temperatures, over-discharge, over-charge, battery specific behaviour and management such as: gassing, equalisation, sulphation, stratification, plate) corrosion, sludge shorting and electrolyte specific gravity (SG); 2.10 Identify the installation requirements for safety, performance and ease of operation and maintenance; 2.11 Describe the different techniques used to measure battery bank capacity, e.g. by the use of specific gravity measurements and charts or by a measured discharge test.
Learning Outcome 3 (LO3)	Conduct ***site assessment***
Performance Standards	3.1 Analyse client situation, budget and desired outcomes to be incorporated into system design; 3.2 Assess site to determine feasibility, equipment location and any required switchboard modification; 3.3 Identify available components and apply appropriate system configuration to system design; 3.4 Undertake energy assessments using appropriate tools including data logging tools and/or energy assessment forms; 3.5 Identify electrical load/s to be supplied from the battery storage system for different system requirements (also termed as specified loads);

	3.6 Interpret solar radiation data available from different sources and equipment.
Learning Outcome 4 (LO4)	Carry out sizing system components
Performance standards	4.1 Select most appropriate system equipment and corresponding configuration to meet client requirements based on comparing merits with alternate configurations including maintenance requirements; 4.2 Apply system efficiencies to system designs and overall system yield for different system configurations and for the chosen configuration; 4.3 Select and size electrical load(s) to be supplied from the battery storage system, also termed as specified loads. **Inverter** 4.4 Determine rating of inverter(s) to meet performance requirement and operation requirement of the battery bank (and PV if applicable); 4.5 Identify appropriate location for housing inverter(s) and determine installation requirements. **Battery Bank** 4.6 Determine the type and rating of battery storage to meet inverter operation and performance requirements; 4.7 Identify appropriate location for housing battery bank and determine installation and ventilation requirements. **PV Array** 4.8 Determine size of PV array depending upon desired system function and any equipment configuration constraints to meet inverter/charge controller operation requirements and performance requirements. **Balance of Systems** **System Cabling and Circuit Protection** 4.9 Determine minimum cable size based on current carrying capacity and voltage drop; 4.10 Calculate voltage drop for all conductors in a grid connected PV system with battery storage;

	4.11 Specify appropriate protection and isolation for all conductors in a circuit for a grid connected PV system with battery storage and calculate their ratings; 4.12 Specify suitable mechanical protection for cable and accessories in the system.
Learning Outcome 5 (LO5)	Carry out installation procedures of system components
Performance standards	5.1 Apply relevant AS/NZS standards and SEIAPI Technical guidelines in battery system installation. **Batteries** 5.2 Demonstrate safe handling with different types of battery systems; 5.3 Discuss battery system/BESS installation in relation to factors which effect 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); 5.4 Demonstrate appropriate placement for installation of batteries to optimize inter-cell connections and minimize excessive cable lengths. (Batteries to be installed in accordance with manufacturer's specifications); 5.5 Discuss different system enclosures and terminal shrouds that are required to meet the climatic conditions in the pacific Islands especially; 5.6 Discuss the requirements for a safe working environment with respect to installation of the battery for the system owners; 5.7 Demonstrate the appropriate placement of inlet and exhaust ventilation apertures (lead acid batteries). **Inverter(s)** 5.8 Demonstrate the correct positioning and sound mounting techniques for: • securely locking the inverter to its supporting structure • ensuring that the inverter is not adversely affected by the harsh environmental condition of the pacific islands. • providing suitable airflow • meeting the installation requirements specified by the manufacturer

	• providing a safe working environment and safe installation for the system owners • minimizing cable lengths **Balance of System Components** 5.9 Demonstrate the positioning and fixing of all system components of a grid connected PV system with batteries in place to: • minimize cable lengths between all components • be installed in accordance with manufacturers specifications • provide a safe working environment and safe installation for the system owners 5.10 Describe the required metering/data logging requirements; 5.11 Demonstrate installation of the meter to meet local utility's or any other mandatory requirements. **Earthing (Grounding)** 5.12 Discuss the requirements of earthing (grounding) systems as specified and required for grid connected PV system with batteries; 5.13 Discuss the requirements for lightning protection systems if specified.
Learning Outcome 6 (LO6)	Carry out ***testing*** and ***commissioning***
Performance standards	6.1 Conduct visual inspection of entire installation, identifying and resolving any deficiencies in materials or workmanship for the grid connected PV system with batteries; 6.2 Check visually the system mechanical installation for structural integrity and weather sealing as required; 6.3 Check visually the electrical installation for proper wiring practice, security of terminations, insulation damage and secure grounding/earthing; 6.4 Test the electrical installation for polarity, continuity, insulation integrity and grounding/earthing; 6.5 Verify overall system functionality and performance, compare with expectations; 6.6 Demonstrate correct sequence for connecting and disconnecting the system and equipment from all sources; 6.7 Verify all markings and labels for system and equipment have been installed as required;

	6.8 Identify and explain all safety issues associated with operation and maintenance of grid connected PV system with batteries; 6.9 Produce a complete installation documentation package for the system and equipment to be handed to owner/operator.
Learning Outcome 7 (LO7)	Carry out ***maintenance*** and ***troubleshooting*** systems
Performance standards	7.1 Identify tools and equipment required for maintaining and troubleshooting grid connected PV system with battery storage and demonstrate proficiency in their use; 7.2 Identify maintenance needs and implement service procedures for modules, arrays, inverters, batteries, safety systems, structural and weather sealing systems.; 7.3 Identify performance and safety issues and implement corrective measures; 7.4 Verify complete functionality and performance of system, including start-up, shut-down, normal operation; 7.5 Update records of system operation, performance, and maintenance; 7.6 Develop the system maintenance report/documentation that should be provided to the system owners.
Pre-requisites	Passed NS 122-04 Determine sizing and installation of grid connected PV system
Co-requisites	N/A
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 installation; 4. Knowledge of basic functions and components of solar PV systems; 5. Basic knowledge of installing solar PVs. **Skills** 6. Safe working principles and equipment handling skills 7. Installing grid connected PV systems; 8. Test and commission grid connected PV systems; 9. Performing checks on 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: i) Tutorial exercises on important topics in preparation for the final examination ii) Design Task – sizing a complete grid connected PV system with battery storage iii) Final examination d) Practical assessment: Assessment of sizing and install skills to denote competency in grid connected PV systems with battery storage ***The student needs to be competent in the design task, 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. One or two small-scale grid connected PV system with battery storage including equipment, tools and accessories for installation, maintenance and fault-finding including all major equipment (battery, array, PV inverter, battery inverter etc) 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 system with battery storage. 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 • Rachet 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, Battery Storage Systems for Grid-Connected PV Systems (3rd 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: Grid Connected PV Systems with Battery Energy Storage Systems Design Guidelines and Grid Connected PV Systems with Battery Energy Storage Systems Installation Guidelines 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. ***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. ***Balance of system*** refers to all the hardware, software, and structural components of a power system *excluding* the actual energy generators (like solar panels or wind turbines). It encompasses everything required to capture, convert, regulate, and safely distribute the electricity. 3. ***Battery*** is a device that stores energy in chemical form and converts it directly into electrical energy or demand. 4. ***Battery bank*** is a collection of individual batteries connected together to act as a single, larger energy storage system. 5. ***BESS*** refers to Battery Energy Storage System. It is a technology that captures electrical energy and stores it in rechargeable batteries so it can be dispatched and used later. 6. ***Circuit protection*** refers to the safety mechanisms used in electrical systems to automatically interrupt the flow of electricity during a fault. 7. ***Earthing (or grounding)*** is a safety system that connects the metal parts of electrical equipment to the earth.

	8. ***Grid connected PV with Battery Storage (GCPVwBS)*** refers to a solar power setup that generates electricity from sunlight and connects to the local utility grid, while also including a battery system to store surplus energy for later use. 9. ***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. 10. ***Hazards*** refer to any situation or dangerous condition where contact with electrical systems or exposed conductors can cause harm, injury, or property damage. 11. ***Inverter*** is an electronic device that converts Direct Current (DC) electricity into Alternating Current (AC) electricity. 12. ***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). 13. ***PV array*** is a linked collection of multiple solar panels functioning together as a single electricity-producing unit. It captures sunlight and converts it ingo usable power. 14. ***Site assessment*** (or site survey) is a structured on-site evaluation determine if a location can safely and const-effectively support new electrical loads or power systems. 15. ***Specific gravity*** measures the density of a liquid electrolyte (like the sulfuric acid in a lead-acid battery) compared to the density of pure water. 16. ***System cabling*** refers to organized, standardized and integrated wiring setups often called structured cabling designed to manage multiple power, data, and communication needs within a building.
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.