1. Module details

Module name

Stand-alone renewable power system components

Module duration

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 60 hours.

Module code

NUER04

Discipline code

1105

2. Module purpose

This module provides knowledge and skills relating to the function, operation and specifications and testing of components used in stand-alone power systems. It is intended as a companion and prerequisite to NUER02 – Photovoltaic Power Systems.

3. Prerequisites

NUER01 – Introduction to Renewable Energy Technologies;
NUER03 – Electronics for Renewable Energy Systems *or*
NUER17 – Introduction to Electronics for Renewable Energy

4. Relationship to competency standards

This module provides part of the underpinning knowledge and skills identified in the 'Evidence Guide' of specific units in the National Electrotechnology Competency Standards, namely NES219, NES305, NES412, NES506, NES710.

5. Content

ELV wiring and protection

identifying ELV and LV circuits, regulations
earthing
ELV cable sizing, allowable voltage drops, current carrying capacity
circuit protection sizing and selection esp. for inverters, isolation

System diagrams

Block diagrams for typical stand-alone renewable power system configurations
Complete schematics for stand-alone renewable power systems
Architectural and site diagrams
Schedule of equipment

Batteries

Battery types for stand-alone power systems, basic chemistry, structure, advantages and disadvantages
battery life
sulphation and stratification

- depth of discharge and temperature effects
- charging regimes
- specifications
- estimation of cycle life
- safe practices for handling and disposal

Balance of system components

- operating principles, features and specifications of inverters
- performance of loads on non-sine waveforms, avoiding problems
- power factor and correction
- operation of regulators and battery chargers
- Maximum Power Point Trackers (MPPTs)
- advantages and disadvantages of mechanical trackers

Basic lighting design

- lamp types and properties
- effect of luminaire design and position; decor, room construction and windows
- energy efficiency considerations
- selection and sizing of lamps for stand-alone PV systems

Generating set construction and operation

- Genset components
- Internal combustion engines:
  - types
  - construction
  - operation
  - fuel types and ignition methods
  - mechanical coupling
  - speed governing systems
- Alternators:
  - construction
  - components
  - excitation methods and voltage regulation
  - operation of brushless excitation and self-excitation
  - voltage control
- Operating characteristics, advantages and disadvantages of
  - petrol, diesel, gas
  - naturally aspirated, turbocharged
  - high and low speed
  - single and multi-cylinder.
- Response to step load change; overload
- Hunting: symptoms, causes and solutions

Genset performance and sizing Calculations

- Prime mover and alternator ratings
- Power calculations for real, apparent and mechanical power

Calculations for voltage regulation and speed
Derating calculations
Gensets sizing: real and apparent power requirements; maximum demand and surge loads;
Fuel Consumption
Overall efficiency
Average efficiency when supplying a given daily load profile

6. Assessment strategy

Assessment methods

Assessment should encompass both progressive and holistic elements in recognition of the interdependence between learning outcomes and to ensure the module purpose is met. To assist in ensuring validity, reliability and fairness, assessment instruments should include both practical exercises and written exercises consisting of a number of item types, such as multiple choice, short answer and problem solving.

Conditions of assessment

Normally learning and assessment will take place in a classroom/ laboratory environment.

7. Learning outcome details

Learning outcome 1

Select and size ELV wiring and circuit protection for renewable power systems.

Assessment criteria

1.1 Identify extra low voltage (ELV) and low voltage (LV) circuits in a stand-alone or grid connected renewable power system and the regulatory restrictions regarding work at each level.

1.2 Describe the earthing requirements for renewable power systems over a range of applications and environments.

1.3 Calculate the required sizes for ELV cabling in a renewable power system, considering allowable voltage drops and cable current carrying capacity, in accordance with AS/NZS 3000 and AS 4509.

1.4 Select and size suitable d.c. circuit protection and isolation for all relevant points in a stand-alone renewable power system, in accordance with AS/NZS 3000 and AS 4509.

Learning outcome 2

Produce all relevant electrical diagrams for a renewable power system according to Australian Standards SAA HB3 and AS/NZS 3000.

Assessment criteria

2.1 Draw functional block diagrams for typical stand-alone renewable power system configurations.

2.2 Draw and label a circuit schematic of typical renewable power systems supplying d.c. and/or a.c. loads, including all major components, protection devices, earthing, isolation, switching and metering.

2.3 Draw and label a unit wiring diagram for a typical renewable stand-alone power system d.c. control board.

2.4 Mark up architectural and site diagrams to show the locations of equipment, fittings and cabling.

Learning outcome 3

Describe the operation and performance of batteries for stand-alone renewable power system applications.

Assessment criteria

3.1 Outline the major features of each of the major types of commercially available batteries for stand-alone power system applications including basic chemistry, physical structure, advantages and disadvantages.

3.2 Outline the factors affecting the life of a battery.

3.3 Describe the processes of sulphation and stratification in lead acid batteries, their causes, effects and methods of prevention or reduction.

3.4 Describe the effect of depth of discharge and of temperature on the capacity and life of lead-acid batteries.

3.5 List the major specifications for a lead-acid battery in a stand-alone power system application.

3.6 Briefly describe the main features of charging regimes suitable for the major types of stand-alone power system batteries, using real examples.

3.7 Estimate the life of a standalone power system battery in years, based on manufacturer's cycle life data and given capacity, configuration and operating conditions.

3.8 Outline the precautions required when handling, installing or maintaining lead-acid batteries.

3.9 Outline the procedures required for safe disposal of the major commercially available types of batteries in accordance with AS 4509.

Learning outcome 4

Describe the operation and performance of balance of system components and common loads.

Assessment criteria

4.1 Compare the features of at least two commercially available inverters suitable for use in stand-alone power systems.

4.2 Measure the major operating parameters of an inverter, including d.c. voltage operating window; efficiency, output voltage waveform and output voltage regulation over a range of loads up to 5 minute ratings.

4.3 Describe the problems that may be caused by non-sine supply voltage waveforms on typical loads, and the solutions used to overcome these.

4.4 Describe the significance of low power factor loads for inverter systems and the principle of power factor correction.

4.5 Describe the operation of the major types of regulators for use in stand-alone renewable power systems, using commercially available equipment as examples.

4.6 Measure the current vs voltage characteristics, efficiency and charging voltage waveform for a transformer/rectifier type and a switchmode type battery charger suitable for use in stand-alone renewable power systems.

4.7 Outline the operation of and applications for MPPTs for photovoltaic arrays.

4.8 Outline the basic operation, advantages and disadvantages of mechanical tracking devices for PV arrays.

4.9 Read and set control parameters or data using digital displays on inverters, regulators or controllers.

Learning outcome 5 **Perform basic lighting design for a house.**

Assessment criteria

5.1 Outline the properties and features of the major lamp types including their suitability for use in stand-alone PV power systems.

5.2 Describe the effect on room lighting levels, of luminaire design and positioning, décor, room construction and windows.

5.3 Select and size suitable lamps and fittings and their placement in a household taking into account usage, lighting levels required by relevant standards, and energy efficiency considerations.

Learning outcome 6 **Describe the construction and operation of an internal combustion engine driven generating set.**

Assessment criteria

6.1 Identify the major components in the construction of a generating set.

6.2 Identify the main components of gas, petrol or diesel internal combustion engines.

6.3 Describe the basic principle of operation of internal combustion engines, including different fuel types and ignition methods.

6.4 Outline the operating characteristics, advantages and disadvantages of gensets using different fuel types, aspiration methods, operating speed and number of cylinders.

6.5 Outline the major methods of mechanical coupling and power transmission between an engine and alternator.

6.6 Outline the function and ratings of mechanical and electronic speed governing systems.

6.7 Describe the basic structure and operation of an alternator.

6.8 Outline the advantages and disadvantages of different types of excitation system and voltage regulation used for genset alternators.

6.9 Outline the components and basic operation of a brushless excitation system in an alternator, and the principle of self-excitation.

Learning outcome 7

Perform calculations relating to the sizing and performance of gensets.

Assessment criteria

7.1 List the major electrical and mechanical ratings which control the performance of a genset.

7.2 Perform calculations relating to real and apparent power, power factor, mechanical power, voltage regulation and speed droop for single phase gensets.

7.3 Calculate the derating factor for a genset given manufacturer's derating data and a given set of operating conditions.

7.4 Select and size a suitable genset given maximum demand and surge loadings and derating factor.

7.5 Calculate the fuel consumption of a genset given manufacturer's data and operating conditions.

8. Delivery of the module

Delivery strategy

Delivery strategies must be suitable for learning both theoretical and practical aspects described in the module purpose. It is considered that the most effective way to achieve this is by the integration of theory and practice where students learn by experimentation and through practical experience in working with real systems.

It is recommended that learning and assessment be facilitated in a holistic manner. In particular, system components should be examined in the context of a whole system, through the use of system examples and case studies. The learning outcome sequence may be other than that indicated in the module.

Resource requirements

Resources should be sufficient for students to carry out experiments in pairs. This will require a range of experimental devices and measuring instruments and programming of activities to allow access to costly equipment in turn.

Copies of all relevant standards are required.

Occupational health and safety requirements

A safe and healthy environment will be provided for students and teachers as well as safety procedures with regard to learning / teaching activity according to local OH&S regulations.

The following OH&S issues are to be addressed in the appropriate learning outcome(s):

General:

- lifting and carrying
- eye/skin/ear protection
- use of power tools
- keeping work areas tidy

Electrical:

- use of measuring meters
- isolation procedures
- work with battery installations (Eg. hydrogen explosion, acid spillage, ventilation, short circuits)

Minimum physical resources	Photovoltaic regulators,
Suggested References	AS 4086.2:1997 *Secondary Batteries for use with stand-alone power systems.* Part 2: *Installation and Maintenance*

AS/NZS 3000:2000 *Wiring Rules*

AS 4509.1:1999 *Stand Alone Power Systems.* Part 1: *Safety Requirements*

AS 4509.2:2002 *Stand Alone Power Systems.* Part 2: *Design Guidelines*

AS4509.3:1999 *Stand Alone Power Systems.* Part 3: *Installation and Maintenance*

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