1. Module details

Module name

Hybrid Energy Systems

Module duration

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 80 hours.

Module code

NUER09

Discipline code

1105

2. Module purpose

This module provides knowledge and skills in the operation, design, installation, commissioning and maintenance of hybrid power systems, based on an energy services approach. Data logging, data communications, and detailed life cycle cost analysis are also covered. Knowledge and skills relating to parallel hybrid systems with automatic genset control and nominal daily genset running are emphasised.

3. Prerequisites

NUER02 Photovoltaic Power systems

It is recommended but not essential that students have also completed NUER06 – Wind Energy Conversion Systems I and/or NUER05 Micro-hydro Systems.

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 NES411 and NES709.

5. Content

Energy demand

end-use, primary energy demand assessment
energy source options
matching energy sources to services
load profiles

Hybrid system operation

terminology
advantages/disadvantages of hybrid systems
configurations
case study – daily and seasonal operation

System design

design steps and criteria
end-use services, energy demand,
resource assessment
system configuration
select and size components, especially battery, genset and

inverter for systems with nominal daily genset running
system performance prediction using software
optimise the design
genset run time and fuel usage
energy fraction contributed by each source

Life cycle costing (LCC)

Present worth
major costs
simple payback
discount rates, inflation rates and other major parameters
impact of cost of finance and tax savings on LCC
LCC analysis using software
comparison of energy supply options using LCC
sensitivity analysis of LCC

Installation, Commissioning and maintenance

Fuel storage requirements:
- AS 1940, AS 4509, local regulations

Installation requirements:
- ventilation (cooling and combustion air)
- exhaust system
- vibration isolation
- sound attenuation
- modifications for extended service intervals
- safety
- AS 3010, AS 4509

Installation and commissioning of genset and controller
Maintenance schedule
Common genset faults
Diagnose and rectify basic faults
- use of flowcharts and troubleshooting guides
- mechanical
  - fuel system (incl. bleeding injectors)
- electrical
  - start battery, charging system
  - tune or replace AVR
  - flash alternator field
  - start solenoid, starter motor
  - ignition system
  - other electrical
  - controller

Data Communications

typical application for data comms in RE
cabling, connectors, communications ports and protocols,
modems and dial-up connections
terminal or other communications software;

Data Logging

General features
Set up and operate project

Control and Interactive inverters

Features, operation, control philosophies
Specify and program control parameters
Genset controllers

6. Assessment strategy

Assessment methods

Assessment should encompass both progressive and holistic elements in recognition of the interdependence between learning outcomes. 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. A system design project may serve as the major assessment item.

Conditions of assessment

Normally learning and assessment will take place in a classroom/ laboratory environment, or in simulated or actual workplace conditions during installation, commissioning and maintenance work.

7. Learning outcome details

Learning outcome 1

Determine the demand for energy from a hybrid system in terms of end-use energy and primary energy, using appropriate matching of energy sources and services.

Assessment criteria

1.1 Assess the end-use services and energy demand for each service.

1.2 Select the most appropriate energy sources for each energy service for a given application and location, taking into consideration economic, environmental and client requirements.

1.3 Calculate greenhouse gas savings from a hybrid energy system compared to an existing non-hybrid system, resulting from energy source switching and reduction in fuel usage.

1.4 Produce daily load profiles illustrating average demand and maximum demand, based on time of use data for all electrical loads

1.5 Produce daily load profiles based on given load data, with consideration of likely variations in usage patterns.

1.6 Determine load management strategies and or energy source switching options to reduce the maximum and surge demand, based on load profile analysis

1.7 Measure a load profile using a.c. power logging equipment

1.8 Create daily load profiles illustrating average demand and maximum demand, based on time of use data for all electrical loads

Learning outcome 2

Describe the operation of a hybrid energy system.

Assessment criteria

2.1 Explain these terms:
complementarity (in relation to renewable energy resources)
availability

2.2 List the advantages and disadvantages of hybrid energy systems.

2.3 Describe the major features of typical system configurations including:

- pure renewables
- renewables and genset
  - series
  - switched
  - parallel (including those with nominal daily genset running)

2.4 Using a case study, describe the operation of a hybrid system over the short term (e.g. daily) and long term (e.g. seasonal, annual).

2.5 Describe the response of a genset to a step change in load, and to an overload condition.

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

2.7 Calculate the average efficiency of a genset supplying a given daily load profile, given genset efficiency vs load data.

Learning outcome 3

Design a renewable energy based hybrid energy system to meet given design criteria at a given location in accordance with relevant Australian standards.

Assessment Criteria

3.1 Determine system design criteria in consultation with a client.

3.2 Assess the renewable energy resources available at a site through the use of on-site measurements and pre-existing weather data as appropriate.

3.3 Select a suitable hybrid power system configuration.

3.4 Select and size suitable renewable energy generators for a hybrid energy system taking into consideration available renewable energy resources and daily and seasonal load profiles consistent with AS 4509.2.

3.5 Analyse load data to determine preferred time of day for genset running, and required energy storage in a parallel hybrid system.

3.6 Select and size a suitable genset for any system configuration, including a parallel system, according to AS 4509.2

	3.7	Select and size suitable balance-of-system components for a hybrid energy system including energy storage, controls and inverters consistent with AS 4509.2.
	3.8	Select and size a battery bank to meet both energy and maximum power demands in a parallel hybrid system, using an appropriate battery discharge rate and considering load data and genset running times.
	3.9	Select and size an inverter for a parallel hybrid system, considering load data, genset running times and battery charging requirement.
	3.10	Select and size suitable internal combustion generators (genset) for a hybrid energy system taking into consideration genset characteristics and de-rating requirements.
	3.11	Predict the performance of the system given load data, resource data, equipment specifications, configuration and control strategy.
	3.12	Calculate the load fraction contributed from each renewable energy generator and from the genset.
	3.13	Calculate genset run time and fuel usage.
	3.14	Optimise the system design based on a mix of design criteria such as cost, availability and reliability, maintenance, environmental factors, convenience etc.
	3.15	Produce a system manual according to AS 4509.3 and AS 4509.2, given system components and design data.
Learning outcome 4	**Determine the most cost effective option for a hybrid energy system by undertaking a life cycle costing to Australian Standards AS 4536 or AS 3595.**	
Assessment Criteria	4.1	Calculate the present worth of a future payment.
	4.2	Identify the major costs in the life cycle of a hybrid energy system to be considered in life cycle costing.
	4.3	Select appropriate discount rate, inflation rates, and life cycle for a hybrid system life cycle cost analysis.
	4.4	Perform a life cycle cost analysis including the cost of finance and tax savings for a hybrid system using computer software.

4.5 Select the most cost effective of a number of hybrid energy system options on the basis of life cycle costing analysis according to AS 4536, AS 3595 or similar standards.

4.6 Compare the capital cost, simple pay back time and life cycle cost of a hybrid energy system with another energy supply option, according to AS 4536, AS 3595 or similar standards.

4.7 Perform a sensitivity analysis of life cycle costing to variations in discount rate or other major parameters.

Learning outcome 5

Carry out installation, commissioning and maintenance work for a hybrid power system, taking into account safety, correct operation and Australian Standards.

Assessment criteria

5.1 Specify the installation and maintenance requirements for a complete hybrid energy system taking into consideration safety and relevant Australian Standards.

5.2 Specify the installation requirements for fuel storage for a given genset in accordance with AS 1940, AS 4509 and local regulations.

5.3 Outline the considerations involved in providing adequate genset vibration isolation.

5.4 Outline the considerations involved in providing a genset exhaust system suitable for a given genset and installation site.

5.5 Outline the major considerations and methods used in providing suitable noise attenuation for a genset installation.

5.6 Specify the physical accommodation requirements for a given genset to provide adequate air flow and noise attenuation, with due regard for safety, maintenance access, and in accordance with AS 3010 and AS 4509.

5.7 Outline the methods used to allow extended service intervals for gensets.

5.8 Outline the main features of engine protection systems commonly used on small gensets, and the genset sizes to which these are applicable.

5.9 Perform installation and commissioning work on a small genset and controller observing relevant OH&S guidelines.

5.10 Recognise the symptoms of common genset faults.

5.11 Perform basic fault location and rectification on a genset with the aid of troubleshooting guides or flowcharts.

5.12 Describe the symptoms, causes and possible solutions for the phenomenon of "hunting".

5.13 Produce a complete maintenance schedule for a hybrid power system.

Learning outcome 6 **Set up and use data communications links between a computer and an electronic device in a renewable energy system.**

Assessment criteria

6.1 Describe typical applications of data communications in renewable energy systems.

6.2 List the different types of cables and connectors used in data communications between electronic devices and computers.

6.3 List commonly used protocols used for serial data communications.

6.4 Identify different communications ports on palmtop, laptop or desktop computers.

6.5 Correctly connect an electronic device (e.g. inverter or charge controller) to a computer directly, and via modems and telephony network, using appropriate cabling, connectors and computer ports.

6.6 Set up and use a dial-up connection from a computer to a remote electronic device, such as an interactive inverter.

6.7 Use a standard terminal program or proprietary communications software to send to and receive data from an electronic device.

6.8 Program and retrieve data from an interactive inverter via a computer and data communications link.

6.9 Process, display and interpret logged data downloaded from an interactive inverter.

Learning outcome 7 **Set up and operate a simple data-logging project.**

Assessment criteria

7.1 Describe the general features and operation of on-site and remote data logging systems for monitoring and control of a hybrid energy system.

	7.2	Set up and carry out a simple data logging project including logger programming, data downloading, display and interpretation of the results.
Learning outcome 8	**Specify and program a control strategy for a hybrid power system using an interactive inverter.**	
Assessment Criteria	8.1	Describe the main features of different devices commonly used as controllers in hybrid energy systems.
	8.2	Briefly describe the function and operation of an interactive inverter.
	8.3	Compare the system control philosophies used in two different interactive inverters.
	8.4	Specify all program parameters for an interactive inverter, as required for the correct operation of a parallel hybrid system given system component details, load data and preferred genset running times.
	8.5	Determine an appropriate charging regime for the system battery, based on manufacturer's data and system operating conditions.
	8.6	Correctly program an interactive inverter through its front panel interface.
	8.7	Outline the function, operation and major features of a genset controller and how it interfaces with a system controller such as an interactive inverter.

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. A system design project may serve as the major assessment item on which a large part of the teaching and learning will focus. This may also facilitate the integration of learning about individual system components. The learning outcome sequence may be other than that indicated in the module.

Resource requirements

Resources should be sufficient for students to carry out practical work in pairs. This will require a range of commercially available system components, tools, experimental devices and measuring instruments, as well as access to sites or training facilities for system installation and maintenance.
A computer laboratory, system design software and 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
- working on roofs
- keeping work areas tidy
- rotating machinery
- burns from hot parts (e.g. exhaust)

Electrical:

- use of measuring meters
- isolation procedures
- use of ladders

work with battery installations (Eg. hydrogen explosion, acid spillage, ventilation, short circuits)

Minimum physical resources

Access to a small hybrid energy system including:
- PV array of at least 300 W rating,
- Recommended but not essential: wind turbine and tower, or micro hydro turbine,
- Small diesel generator and genset controller
- Battery storage,
- Genset interactive inverter
- Other system components e.g. regulators

Access to sites for installation and maintenance work (may be simulated)
Compass, inclinometer or other shading assessment tool.
Meters, oscilloscope and other test equipment.
Hand and power tools for system installation and maintenance
Solarimeter, multimeters, computers
Hydrometer
Glass thermometers
Safety equipment e.g., rubber gloves, rubber boots, plastic/rubber apron, face shield.
Computer software to analyse the performance and life cycle cost of hybrid energy systems.

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