1. Module details

Module name

Introduction to Renewable Energy Technologies

Module duration

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 72 - 80 hours.

Module code

NUER01

Discipline code

1105

2. Module purpose

This module is an introduction to renewable energy (RE) technologies with an emphasis on commercially available technology and small-scale applications. It provides:

- an awareness of economic, political, environmental and social issues impacting on the application of RE technologies
- knowledge and skills in the assessment of energy services, demand and efficiency strategies
- knowledge and skills in resource and site assessment for solar, wind, small hydro, and biomass
- knowledge of solar thermal systems and energy efficient building design features;
- knowledge of, and simple sizing methods for, household scale stand-alone power systems including photovoltaics, wind energy conversion systems and micro-hydro systems

It combines both theory and its application to real situations.

3. Prerequisites

Nil

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. The relevant units are: NES112, NES113, NES114, NES219, NES305, NES412, NES413, NES506, NES601, NES709, NES710.

5. Content

Non-technical issues

current economic, social, environmental and political issues, impact on a renewable energy technology

Energy services/demand

terminology
energy, power, temperature, symbols, units
energy conversion and efficiency
domestic dwelling: energy services, energy source selection, energy auditing
primary energy and end use energy
embodied energy

Solar radiation resource

terminology

units, symbols, conversions
sun position, sun path diagrams
solar radiation on fixed and tracking collectors

Solar thermal systems

terminology
components
applications
types of hot water systems
system features, orientation, tilt angles, placement
system selection, solar fraction

Energy efficient building design

terminology
climate and thermal comfort
thermal conductivity of building elements
solar heat gain
ventilation
glazing
thermal mass
insulation
shading devices
siting of buildings
active solar systems

Photovoltaic arrays

terminology
current, voltage and power
modules: types, efficiency, applications
IV curve
irradiance and temperature effects
blocking and bypass diodes
circuit diagrams, array configurations
major specifications, preliminary sizing

Wind energy resource and technology

terminology, units, symbols
wind patterns (Australia)
local terrain, wind speed, direction, turbulence, wind power
maps, data sheets, measuring instruments
Wind Energy Conversion Systems (WECS)
terminology
characteristics
applications
major specifications, preliminary sizing

Micro-hydro resource and technology

terminology, units, symbols
flow rate, head, assessment
turbine types, operating characteristics

major specifications, preliminary sizing

Energy storage

terminology
types and methods
battery life, temperature effects, charge and discharge rates
precautions, maintenance, safety
stratification, sulphation
boosting and equalising charges
major specifications, capacity, configuration
types, sizes

Stand-alone power system configuration

basic configuration
components: functions, efficiencies; regulators, inverters, battery chargers, generators

Biomass resource and technology

terminology
common biofuels: types, energy contents, production, applications
resource assessment

6. Assessment strategy

Assessment methods

Assessment should be progressive reflecting an holistic approach to ensure the module purpose is met. To assist in ensuring validity, reliability and fairness, assessment instruments should include practical exercises, assignments 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

Describe the major non-technical issues and their impact on the application of a renewable energy technology eg domestic solar hot water.

Assessment criteria

1.1 List the main non-technical issues ie economic, social, environmental and political, impacting on the use of renewable energy technologies.

1.2 Explain how each of the non-technical issues in 1.1 impact on the application of a selected renewable energy technology.

Learning outcome 2

Assess the energy services and energy demand for a domestic dwelling to provide energy efficiently and maximise the use of renewable energy.

Assessment criteria

2.1 Define these terms:
energy
power
energy efficiency
end use energy
primary energy
embodied energy

2.2 Perform calculations relating to energy, power and time with the appropriate number of significant figures.

2.3 Write the units and symbols for energy, power, time and temperature using standard SI units and prefixes.

2.4 Convert energy and power quantities from one unit to another using conversion tables.

2.5 Apply the two laws which apply to any energy conversion process.

2.6 Calculate the efficiency of a simple energy conversion process.

2.7 List the energy services required by a domestic dwelling.

2.8 Determine the power and energy consumption of individual appliances and systems using appropriate meters or other methods.

2.9 Calculate the end use and primary energy required for these energy services.

2.10 Select the most appropriate energy source for each of these services.

2.11 Justify your selection in terms of environmental, economic, social and political constraints.

2.12 Select appropriate energy efficient appliances and technologies.

Learning outcome 3

Determine the daily average solar irradiation for each month falling on a collector at an appropriate tilt angle for a given application eg hot water, refrigeration.

Assessment Criteria

3.1 Define these terms:
- irradiation
- latitude
- solar constant
- direct and diffuse radiation
- azimuth and altitude angles
- irradiance
- solar window
- tilt angle
- solstice
- equinox

3.2 Write the units and symbols for irradiation and irradiance.

3.3 Convert irradiation and irradiance quantities from one unit to another using conversion tables.

3.4 Measure solar irradiance with a solarimeter.

3.5 Interpret solar radiation data tables and solar contour maps.

3.6 Locate the position of the sun for a given date, time and latitude using a sun path diagram.

3.7 Determine the times when an obstacle will shade a given collector.

3.8 Explain how radiation varies throughout the year on the surface of a collector which is either fixed, single-axis tracking or double-axis tracking.

3.9 Select appropriate tilt angles for fixed and seasonally-adjustable collectors at a given latitude and for a given application.

3.10 Calculate the effect of single-axis tracking and double-axis tracking on collected radiation using radiation data tables.

Learning outcome 4

Determine the size and type of an appropriate solar thermal system for a given load, location and application

Assessment criteria

4.1 Define these terms:
- conduction
- convection
- radiation
- collector heat loss co-efficient
- conductivity
- specific heat
- solar fraction

4.2 Describe the components for a solar thermal system including collector, storage, reticulation and control.

4.3 Describe solar collector types suitable for low, medium and high temperature applications.

4.4 Describe the different types of domestic solar hot water (SWH) systems.

4.5 Describe the following:
- how the components of thermosiphon and pumped storage systems operate
- heat loss mechanisms in collectors
- stratification in storage tanks
- backup energy systems
- control and protection strategies

4.6 Determine appropriate orientation, tilt angle and placement of domestic solar water heating systems.

4.7 Determine the solar fraction of a domestic SHW system with the use of tables or nomograms.

Learning outcome 5

Describe the features of a building which affect its thermal performance for a given climate and site

Assessment criteria

5.1 Explain the terms:
- thermal comfort
- passive system
- active system
- aspect of the site
- orientation of the building
- thermal mass

5.2 Describe the climate factors, which affect building design.

5.3 Explain the following in qualitative terms:
- the relationship between thermal comfort and climate
- the relationship between the seasonal variation of the suns's path and the heat gain of the building elements (roof, walls, windows, floor)
- the effect of the thermal conductivity of building materials on heat flows to and from the building
- the use of thermal mass in reducing temperature variations within the building
- the use of ventilation

5.4 Monitor the thermal performance of a dwelling using both indoor and outdoor hourly temperature measurements over the period of at least one day.

5.5 Describe the effect of insulation, glazing, orientation, shading devices, thermal mass and ventilation on the thermal performance of a building.

5.6 Describe an active solar system which could be used in a dwelling to complement passive design features in extreme climates.

5.7 Identify aspects of an existing dwelling which contribute to or detract from thermal performance.

Learning outcome 6

Select a fixed photovoltaic (PV) array of a suitable size for a given load and location.

Assessment criteria

6.1 Define the terms:
- photovoltaic (PV) cell
- module
- series, parallel
- array
- maximum power point (MPP)
- Nominal Operating Cell Temperature (NOCT)
- Short Circuit Current (I_{SC})
- Open Circuit Voltage (V_{OC})
- I-V Curve
- Current at maximum power point (I_{MP})
- Voltage at maximum power point (V_{MP})

6.2 Perform calculations relating to voltage, current and power with the appropriate number of significant figures and using standard SI units and prefixes.

6.3 Distinguish between the types of commercially available PV modules, their efficiency and typical applications.

6.4 Draw an I-V curve for a typical PV module and label the approximate position of MPP and values of I_{SC}, V_{OC}, I_{MP} and V_{MP}.

6.5 Describe the effect of irradiance and temperature on I_{SC}, V_{OC}, I_{MP} and V_{MP}.

6.6 Describe the function of blocking and bypass diodes.

6.7 Measure the current and voltage of a single module to produce the I-V characteristic curve.

6.8 List the major specification criteria for a PV module.

6.9 Determine the size and configuration of a PV array for a given load and system voltage using tables or nomograms.

Learning outcome 7

Select a suitable type and size Wind Energy Conversion System (WECS) for a given load, location and application.

Assessment Criteria

7.1 Define these terms:
- kinetic energy
- specific wind power
- vertical wind speed profile
- surface roughness
- temperature inversion layer
- cut in (v_C), rated (v_R) and furling (v_F) wind speeds
- rated power (P_R)
- power co-efficient (c_P)
- output co-efficient (c_O)
- tip speed ratio

7.2 Write the units and symbols for wind speed, specific wind power and air density.

7.3 Describe the large scale wind patterns over the Australian continent, their causes and the effect of local terrain on wind speed, direction and turbulence.

7.4 Calculate:
- specific wind power for given wind speeds
- wind speed at different heights above ground level
- the mean wind speed based on wind speed frequency distribution data in the form of a histogram.

7.5 Select a suitable minimum tower height for a Wind Energy Conversion System (WECS) sited downwind from an obstacle.

7.6 Interpret isovent maps.

7.7 Describe types of wind-measuring instruments and the minimum requirements for assessing wind energy at a given site.

7.8 Measure wind speed and direction

7.9 Describe the characteristics of horizontal axis and vertical axis, upwind and downwind, lift and drag propelled wind turbines.

7.10 Draw the power vs wind speed curve for a typical WECS and label v_C, v_R, v_F, and P_R.

7.11 List the major specification criteria for a WECS.

7.12 Size a WECS for a given load, efficiency and annual mean wind speed using tables or a nomogram.

Learning outcome 8

Select a micro-hydro system (MHS) of a suitable type and size for a given load, location and application

Assessment criteria

8.1 Define these terms:
- flow rate
- gross or static head
- potential energy
- net or dynamic head
- hydraulic efficiency
- MHS efficiency
- equivalent pipe length
- reaction turbine
- impulse turbine

8.2 Write the units and symbols for:
- flow rate
- head
- gravitational constant

8.3 Describe three (3) methods each for assessing flow rate and head.

8.4 Measure stream flow rate and head.

8.5 Assess the head from contour maps.

8.6 Distinguish between different MHS in terms of their physical and operating characteristics.

8.7 List the major specification criteria for an MHS for electricity generation.

8.8 Select a suitable type and size of MHS for a given load, efficiency, available flow rate and net head using tables or a nomogram.

Learning outcome 9

Outline the characteristics of one type of energy storage method used in renewable energy applications

Assessment criteria

9.1 Briefly describe at least four (4) methods of energy storage.

9.2 Compare the energy density of the energy storage methods above by mass and volume.

9.3 Define these terms in relation to batteries:
- nominal voltage
- cell
- primary and secondary cells
- battery
- charge and discharge rate
- amp hour capacity
- watt hour capacity
- state of charge (SOC)
- depth of discharge (DOD)
- specific gravity (SG)
- watt hour and amp hour efficiency
- cycle life

9.4 Describe the major features of common types of batteries suitable for stand-alone power systems.

9.5 Determine the state of charge of a lead-acid battery through measurement of specific gravity or battery voltage using safe working practices.

Learning outcome 10

Describe the configuration and function of components in a typical stand-alone power system (SPS).

Assessment criteria

10.1 Explain the term DC sub-system efficiency.

10.2 Draw and label a block diagram of a typical SPS.

10.3 Describe the function of each SPS system component.

10.4 List typical efficiencies of each component.

10.5 Outline the major characteristics of different types of commercially available regulators, inverters and battery chargers.

Learning outcome 11

Assess the use of a biomass resource

Assessment criteria

11.1 Define these terms:
- biogas
- producer gas
- biofuels
- feedstock
- gross and net calorific values

11.2 List five (5) common biofuels and their specific energy contents

11.3 Describe the method of production of one of these five biofuels including:
- source of raw material/feedstock
- conversion process
- yield

11.4 List two (2) applications for each of the biofuels in 11.2.

11.5 Assess the biomass resource required to meet a particular energy service eg cooking, hot water, space heat, transport, process heat, electricity.

11.6 Describe the likely environmental, social, political and economic impact of large-scale use of selected biomass resources.

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 practical application. It is recommended that learning and assessment be facilitated in a holistic manner where possible, which may require learning outcome sequence 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.

Minimum physical resources

Solarimeters
Recording anemometer
Kites
Pressure gauges
Hose, bucket
Digital multimeters
Small stand-alone system, including photovoltaic modules and small wind turbine generator.
Solar hot water system
Safety equipment for battery maintenance including face shield, gloves, protective clothing and footwear.
Digital indoor/outdoor thermometer with minimum and maximum function.
Glass bulb thermometer for use in measuring battery electrolyte temperature.
Good quality hydrometer

Recommended

Ballinger, J.A. Prasad, D.K. and Cassell, D.J. (1992) *Energy*

References and Learning Materials

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Ballinger, J.A., Prasad, D.K. and Rudder, D. (1992) *Energy Efficient Australian Housing*. Australian Government Publishing Service.

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Colls, K. and Whitaker, R. (1990) *The Australian Weather Book: Understanding our climate and how it affects us*, National Book Distributors, Brookvale, N.S.W.
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Fowler, J.M. (1984). *Energy and the Environment*. McGraw-Hill Book Co., Sydney.
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Gregory, J. and Darby, F. (Eds) (1990) *Solar Efficient Design for Housing: A Manual for Architects and Designers*. Melbourne. Victorian Solar Energy Council.
Harvey, A. et al (1993) *Micro-Hydro Design Manual*. Intermediate Technology publications. London
Hawken, P. et al (1999*). Natural Capitalism – The Next Industrial Revolution.* Earthscan Publications, London.
Lee, T, Oppenheim, D, Williamson T.J. *Australian Solar Radiation Data Handbook.* Available from the Aust. and NZ Solar Energy Society email: anzses@unsw.edu.au.
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Monsour P.M., Berrill T.D., et al (1997). *Introduction to Renewable Energy Technologies – Resource Book.* Renewable Energy Centre, Brisbane Institute of TAFE Brisbane, Australia.
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Nunez, M. (1990). *Satellite estimation of regional solar energy statistics for Australian capital cities - Meteorological Study No. 39*. Canberra, Australian Government Publishing Service.
Parnell M. and Cole, G. (1983) *Australian Solar Houses*. Sydney, Second Backrow Press.
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Phillips, R.O., (1987). *Sunshine and Shade in Australasia*. Australian Government Publishing Service, Canberra
Szokolay, S.V. (1982). *Climatic Data and its use in Design.* RAIA Education Division, Canberra.
Szokolay, S.V. (1991) *Climate, Comfort and Energy: Design of Houses for Queensland Climates*. Brisbane. University of Queensland Architectural Science Unit.
Twidell, J.W. Weir A.D., (1986) *Renewable Energy Resources* E. & F. Spon: London
Wenham, S.R. et al (1994). *Applied Photovoltaics*. University of New South Wales, Sydney.
Weizsacker, E. von, Lovins, A.B. & Lovins, L.H. (1997). *Factor Four: Doubling Wealth - Halving Resource Use.* Allen & Unwin, Sydney.
World Commission on Environment and Development (1987). *Our Common Future.* Oxford University Press, Oxford, UK.

Some useful magazines:

- *Solar Progress* (quarterly journal of the Australian and New Zealand Solar Energy Society, c/- Uni of NSW).
- *Renew* (previously called "Soft Technology", published by the Alternative Technology Association, Melbourne – available at news agents).
- *Habitat* (journal of the Australian Conservation Foundation, Melbourne).
- *Wind Power Monthly* (journal of the European Wind Energy Association - available by subscription).

Occupational health and safety requirements

A safe and healthy environment will be provided for students and teachers as well as safety procedure with regard to learning /teaching activity. Particular care should be exercised when working with lead acid batteries to avoid short circuit, acid or explosion due to the presence of hydrogen.