1. Module details

Module name

Fundamentals of Renewable Energy Technologies

Module duration

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 40 hours.

Module code

NUER16

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 appliance energy demand and efficiency;
- understanding of the basic requirements for resource and site assessment for solar, wind, and small hydro applications;
- knowledge of domestic solar water heating system types and operation;
- knowledge of domestic, stand-alone power systems including photovoltaics, wind energy and micro-hydro generators and balance of system components in series configuration.

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, namely NES201, NES202, NES401.

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 and energy demand of individual appliance,

energy efficient appliances
primary energy and end use energy
embodied energy

Solar radiation resource

Terminology
units, symbols, conversions
sun path diagrams
solar contour maps
solar window

Solar thermal systems

Terminology
Components
Applications
types of hot water systems

Photovoltaic arrays

terminology
current, voltage and power
modules: types, efficiency, applications
IV curve
irradiance and temperature effects
array configurations

Wind energy resource and technology

terminology, units, symbols
wind speed, direction, turbulence, wind power,
vertical wind speed profile (wind shear)
local terrain roughness
isovent maps
measuring instruments
Wind Energy Conversion Systems (WECS)
terminology
characteristics
applications

Micro-hydro resource and technology

terminology, units, symbols
flow rate, head, assessment
turbine types and applications

Stand-alone power system configuration

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

6. Assessment strategy

Assessment methods	Assessment should be progressive reflecting a 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 two of the non-technical issues in 1.1 impact on the application of a selected renewable energy technology.

1.3 Outline strategies used by government to increase the uptake of renewable energy technologies.

Learning outcome 2

Assess the energy demand of a range of appliances for a domestic dwelling to provide energy efficiently.

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 first law of thermodynamics to a simple 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 using appropriate meters or other methods.

	2.12 Select appropriate energy efficient appliances and technologies.
Learning outcome 3	**Identify factors that affect the irradiation received on the plane of a collector.**
Assessment Criteria	3.1 Define these terms: irradiance irradiation latitude solar constant direct and diffuse radiation azimuth and altitude angles 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 List 5 factors that effect the amount of irradiation falling on a collector plane Eg. Latitude, orientation and tilt angle of plane, time of year, reflectance from nearby surfaces, cloud cover.
	3.5 Interpret solar irradiation 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 solar window for a given collector with the aid of suitable equipment.
Learning outcome 4	**Describe the operation of 3 types of domestic solar water heating systems (DSWHS).**
Assessment criteria	4.1 Define these terms: Conduction Convection Radiation Conductivity specific heat
	4.2 Describe the configuration and function of the main components for a solar water heating system including collector, storage, reticulation and control.
	4.3 Draw a schematic diagram showing the main components, and configuration of a typical DSWHS.

	4.4 Choose an appropriate DSWHS configuration, orientation, tilt angle and placement for a particular home.
Learning outcome 5	**Distinguish between the different types of commercially available photovoltaic (PV) modules, their efficiency and typical applications.**
Assessment criteria	5.1 Define the terms: Photovoltaic (PV) cell Module Array Short circuit current Open circuit voltage Maximum power point
	5.2 Distinguish between the types of commercially available PV modules, their efficiency and typical applications.
	5.3 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}.
	5.4 Describe the effect of irradiance and temperature on I_{SC}, V_{OC}, I_{MP} and V_{MP}.
	5.5 Describe the function of blocking and bypass diodes.
Learning outcome 6	**Describe the basic configuration and operating characteristics of a Wind Energy Conversion System (WECS) and the likely effect of local terrain roughness on WECS performance.**
Assessment Criteria	6.1 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)
	6.2 Write the units and symbols for wind speed, specific wind power and air density.
	6.3 State the equation for specific wind power and the importance of this equation for wind energy applications.
	6.4 Describe the effect of local terrain roughness on wind speed, direction and turbulence and the variation of wind speed with height above ground level.

	6.5 Measure average wind speed over a short period eg. 10 mins
	6.5 Interpret isovent maps.
	6.7 Distinguish between the different types of WECS according to their number of blades and configuration including horizontal axis and vertical axis, upwind and downwind, lift and drag propelled wind turbines.
	6.8 Draw the Power VS Wind speed curve for a typical WECS and label v_C, v_R, v_F, and P_R.
	6.9 Explain the effects of change in wind speed and swept area on WECS instantaneous power output and potential energy output.
Learning outcome 7	**Distinguish between different configurations of micro-hydro system (MHS) suitable for a given applications.**
Assessment criteria	7.1 Define these terms: Flow rate gross or static head potential energy net or dynamic head hydraulic efficiency MHS efficiency reaction turbine impulse turbine
	7.2 Write the units and symbols for: flow rate head gravitational constant
	7.3 State the factors that determine the power and energy output from a MHS including flow rate, head and overall MHS efficiency (ie. turbine/generator combination), hydraulic efficiency.
	7.5 Assess the head from contour maps.
	7.6 Distinguish between different MHS in terms of their head and flow rate requirements for a given site.
Learning outcome 8	**Describe the configuration and function of components in a typical stand-alone power system (SPS).**

Assessment criteria	8.1	Draw a block diagram of a typical SPS and label the main components including renewable energy generators, regulation, circuit protection, storage, and inverter and back-up genset for a simple series system.
	8.2	Describe briefly the function of each SPS system component.
	8.3	Describe briefly the major features of common types of batteries suitable for stand-alone power systems.
	8.4	List the typical average operating efficiency of the transmission cable, regulator, inverter and battery storage.

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 real life, 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.

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.

Minimum physical resources

Access to:

Recording anemometer

Small stand-alone power system, including photovoltaic modules and small wind turbine and /or micro-hydro generator.

Solar hot water system

Recommended References

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Boyle, G (ed) (1996) *Renewable Energy. The Open University,* Milton Keynes.

Bush, S. (1997). *Australian energy consumption and production: historical trends and projections to 2009-10.* Australian Bureau of Agricultural and Resource Economics (ABARE) Research Report 97.2, Canberra.

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.

Flavin, C. & Lenssen, N. (1994). *Power Surge: a Guide to the Coming Energy Revolution*., W.W. Norton and Co., New York.

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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.

Lowe, I. (1986). *Facing the Future: Energy Options for Australia*. Griffith University Research Lecture Series, Brisbane.

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.

Monsour P.M., Berrill T.D., et al (1997). *Introduction to Renewable Energy Technologies – Student Learning Guide.* Renewable Energy Centre, Brisbane Institute of TAFE Brisbane, Australia.

Pedals, P (1993) *Energy From Nature - A Complete Guide To Independent Energy Systems* Rainbow Power Company , Nimbin, NSW , Australia.

Phillips, R.O., (1987). *Sunshine and Shade in Australasia*. Australian Government Publishing Service, Canberra

Twidell, J.W. Weir A.D., (1986) *Renewable Energy Resources* E. & F. Spon: London

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).