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 54 - 60 hours.

Module code — NUE042

Discipline code — 0703110

2. Module purpose

This module is an introduction to renewable energy technologies and covers topics such as the non-technical issues energy and services requirements, solar radiation, site suitability, micro-hydro systems, biomass, solar thermal systems, building design features, RAPS systems, photovoltaics, wind energy conversion systems, battery storage and sizing for applications. It combines both theory and its applications to real situations.

3. Prerequisites

NUE054 Applied Electricity 2.

4. Relationship to competency standards

This module provides part of the underpinning knowledge and skills in the 'Evidence Guide' of specific units of competency in the National Electrotechnology Training Package and provides similar support, where mapped, to equivalent units in the National Metals and Engineering Competency Standards. For details refer to the module to unit maps, available from NUEITAB.

5. Content

Sustainability issues
Current economic, social, environmental and political issues, impact on a renewable energy technology
Topic review

Energy services/demand
Terminology
Energy, temperature, power, symbols, units
Energy conversion and efficiency
Domestic dwelling: energy services, energy source
Selection
Primary energy and end use energy

Solar radiation resource
Terminology
Units, symbols, conversions
Sun position, sun path diagrams
Solar radiation on fixed and tracking collectors

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
Specifications, sizing

Micro-hydro resource and technology
Terminology, units, symbols
Flow rates, heads, assessment
Turbines
Operating characteristics
Control requirements
Specifications, sizing

Biomass resource and technology
Terminology
Common biofuels: types, energy contents, production, applications
Resource assessment

Solar thermal systems
Terminology
Components
Applications
Types of hot water systems
System features, orientation, tilt angles, placement
System selection, size, cost

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

RAPS system configuration
Configuration
Components: functions, efficiencies
Regulators, inverters, battery chargers, generators

Photovoltaic arrays
Terminology
Modules: types, efficiency, applications
IV curve
Irradiance and temperature effects
Blocking and bypass diodes
Wiring diagrams, configurations
Specifications and sizing

Energy storage
Terminology
Types and methods
Battery life, temperature effects, charge and discharge rates
Precautions, maintenance, safety
Stratification
Boosting and equalising charges
Specifications, capacity, configuration
Operating characteristics
Types, sizes

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 tests consisting of a number of item types, such as multiple choice, short answer and problem solving.

Conditions of assessment

Learning and assessment will take place in an environment that is conducive to a learner's development.

7. Learning outcome details

Learning outcome 1	**Describe the major non-technical issues and their impact on the application of a renewable energy technology such as domestic solar hot water.**
Assessment criteria	1.1 List the main non-technical issues ie economic, social, environmental and political. 1.2 Present a review on a renewable energy topic from a given list and to a specific format. 1.3 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 the terms: - energy - temperature - power - energy efficiency - end use energy - primary energy. 2.2 Differentiate between energy and power. 2.3 Write the units and symbols for energy and power. 2.4 Convert one unit to another using energy and power conversion tables. 2.5 State 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 Calculate the primary energy required for the energy services listed in 2.7.

2.9 Select the most appropriate energy source for each of these services listed in 2.7.

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

2.11 Select appropriate energy efficient appliances and technologies.

Learning outcome 3

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

Assessment criteria

3.1 Define the items:
- irradiation
- irradiance
- latitude
- solar window
- solar constant
- tilt angle
- direct and diffuse radiation
- azimuth and altitude angles.

3.2 Write the units and symbol for irradiation and irradiance.

3.3 Convert one unit to another using conversion tables.

3.4 Measure solar irradiance with a solarimeter.

3.5 Interpret solar radiation data tables and 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 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 — **Select a suitable type and size Wind Energy Conversion System (WECS) for a given load, location and application.**

Assessment criteria

4.1 Define the 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.

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

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

4.4 Calculate the specific wind power for given wind speeds and the wind speed at different heights above a surface.

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

4.6 Interpret isovent maps.

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

4.8 Measure wind speed and direction.

4.9 Describe the characteristics of horizontal axis, vertical axis, upwind, downwind, lift and drag propelled wind turbines and how they relate to particular applications.

4.10 Draw the Power characteristic curve for a typical WECS and label V_C, V_R, V_F, and P_R.

4.11 List the major specification criteria for WECS.

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

Learning outcome 5	**Select a micro-hydro system (MHS) of a suitable type and size for a given load, location and application.**
Assessment criteria	5.1 Define the terms: - flow rate - gross or static head - potential energy - nett head - dynamic head - hydraulic efficiency - MHS efficiency - equivalent pipe length - reaction turbine - impulse turbine.
	5.2 Write the units and symbols for: - flow rate - head - gravitational constant.
	5.3 Describe three methods for assessing flow rate, head and gravitational constant.
	5.4 Measure stream flow rate and head.
	5.5 Assess the head from contour maps.
	5.6 Distinguish between different MHS in terms of their physical and operating characteristics.
	5.7 Describe the features of different types of MHS used for electricity generation and water pumping applications.
	5.8 Distinguish between the control requirements for MHS in battery charging and instantaneous power applications.
	5.9 List the major specification criteria for an MHS for electricity generation.
	5.10 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 6	**Assess the use of a biomass resource.**
Assessment criteria	6.1 Define the terms: - biogas - producer gas - biofuels - feedstock.
	6.2 List five common biofuels and their specific energy contents.
	6.3 Describe the method of production of one of these five biofuels including: - source of raw material/feedstock - conversion process - yield.
	6.4 List two applications for each of the biofuels in 6.4.
	6.5 Assess the biomass resource required to meet a particular energy service eg cooking, hot water, space heat, transport, process heat, electricity.
	6.6 Explain the likely environmental, social, political and economic impact of large scale use of selected biomass resources.
Learning outcome 7	**Determine the size and type of an appropriate solar thermal system for a given load, location and application.**
Assessment criteria	7.1 Define the terms: - conduction - conductivity - convection - specific heat - radiation - solar fraction - collector heat loss co-efficient.
	7.2 Describe the components for a thermal system including collector, storage, reticulation and control.
	7.3 Describe applications according to low, medium and high temperature ranges.

7.4 Describe the different types of domestic solar hot water (SHW) systems.

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

7.6 Determine appropriate orientation, tilt angle and placement of the solar systems.

7.7 Select an appropriate system for specific applications.

7.8 Size a domestic SHW system with the use of tables or nomograms.

Learning outcome 8 **Describe the features of a building which affect its thermal performance for a given climate and site.**

Assessment criteria

8.1 Explain the terms:
- passive system
- active system
- aspect of the site
- orientation of the building
- thermal systems.

8.2 Describe the climate factors which affect building design.

8.3 Explain the following:
- the relationship between thermal comfort and climate
- the relationship between the seasonal variation of the sun'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.

8.4 Select a suitable block of land and locate a building on the block taking into consideration microclimate, shading and aspect.

8.5 Describe the use of insulation, glazing, orientation, shading devices, thermal mass and ventilation in building design.

8.6 Describe how an active solar system can complement passive design features in extreme climates.

8.7 Measure solar irradiance and temperature both inside and outside buildings.

Learning outcome 9 **Describe the configuration and function of components in a typical RAPS system.**

Assessment criteria

9.1 Explain the term DC sub-system efficiency.

9.2 Draw and label a block diagram of a typical RAPS system.

9.3 Describe the function of each RAPS system component.

9.4 List typical efficiencies of each component.

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

Learning outcome 10	**Select a fixed photovoltaic (PV) array of a suitable size for a given load and location.**
Assessment criteria	10.1 Define the terms: - photovoltaic (PV) cell - module - series, parallel - array - maximum power point (MPP) - nominal operating cell temperature (NOCT) - short circuit current (Isc) - open circuit voltage (Voc) - I-V Curve - current at maximum power point (I_{MP}) - voltage at maximum power point (V_{MP}).
	10.2 Distinguish between the types of commercially available PV modules, their efficiency and typical applications.
	10.3 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}.
	10.4 Describe the effect of irradiance and temperature on I_{SC}, V_{OC}, I_{MP} and V_{MP}.
	10.5 Describe the function of blocking and bypass diodes.
	10.6 Measure the current and voltage of a single module to produce the I-V characteristic curve.
	10.7 List the major specification criteria for a PV module.
	10.8 Determine the size and configuration of a PV array for a given load and system voltage using tables or nomograms.

Learning outcome 11

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

Assessment criteria

11.1 List the major categories of energy storage including chemical, gravitational, potential, kinetic energy and heat.

11.2 Compare the basic characteristics of the energy storage methods such as energy density and commercial availability used in renewable energy applications.

11.3 Define the terms:
- nominal voltage
- cell
- 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.

11.4 Describe the major features of common types of batteries, suitable for RAPS systems.

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

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 method to achieve this is by integration of theory and practice where students learn by experimentation, research and reports. It is recommended that learning and assessment be facilitated in a holistic manner that may require learning outcome sequence other than that indicated in the module.

Resource requirements

Suggested learning resources:

Berrill T.D. et al. *Introduction to Renewable Energy Technologies (Education Package).* Ithaca College of TAFE, Brisbane, 1990.

Energy Victoria. *Rural and Remote Area Power Supplies for Australia.* A.G.P.S., Canberra, 1993.

Fowler, J.M. *Energy and the Environment.* McGraw-Hill, Sydney,1984.

Frick, R.A. et al. *Australian Solar Radiation Data Handbook* NERDDC Report No. 938, 1987.

Kreider F. J. & Kreith, F. *Solar Energy Handbook.* McGrawHill, Sydney, 1981.

Meteorological Aspects of the Utilisation of Wind as an Energy Source. WMO Technical Note No. 175, Publication WMO No. 575. World Meteorological Organisation, Geneva, 1981.

Szokolay, S.V. *Climatic Data and its Use in Design.* RAIA Education Division, Canberra, 1984.

Twidell J. W. & Weir A. D. *Renewable Energy Resources.* E. & F. N. Span, London, 1986.

Wegley, H. L. et al. *A Siting Handbookfor Small Scale Wind Energy Conversion Systems.* Windbooks, Washington, USA, 1980.

Minimum physical resources:
Solarimeters
Recording anemometer
Kites/balloons
Pressure gauges
Hose
Digital multimeters
Small RAPS system
Flat plate solar collector
Safety equipment for battery maintenance
Thermometers: globe, wet and dry bulb, digital, glass
Hydrometer

Occupational health and safety requirements

A safe and healthy environment will be provided for students and teachers as well as the particular safety procedures followed as part of the learning / teaching activity and content.