1. Module details

Module name

Wind Energy Conversion Systems 1

Module duration

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

Module code

NUER06

Discipline code

1105

2. Module purpose

This module provides training in the design, application, installation, commissioning and maintenance of stand-alone, wind energy conversion systems to about 10 metres rotor diameter. This module is consistent with Australian Standards AS 1170.2, AS 3000, AS 3011.1 and AS 4509.

3. Prerequisites

NUER02 - Photovoltaic Power Systems,
NUER18 - DC and AC machines for small scale renewable energy 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 NES114, NES219, NES305, NES411, NES412, NES506, NES709, NES710.

5. Content

Characteristics of wind

Terminology
major global wind circulations
formation of major wind flows
local wind systems and patterns
extreme winds

Wind speed data measurement & analysis

Terminology
wind speed and wind energy maps
measurement of wind speed, turbulence and direction
anemometry requirements
data logging requirements
calibration of anemometers
analysis of wind speed and direction data
installation of wind monitoring equipment
regulatory requirements
legal issues eg. Liability & resource access

Site selection

Terminology
topography and vegetation
surface roughness
isolated obstacles
temperature inversion effects
speed-up effects over hills, ridges etc
proximity to homes and buildings
power transmission distance
environmental impacts eg. visual, noise, wildlife
heritage impacts

Wind energy conversion systems (WECS)

Terminology
lift and drag types
characteristics and categories
materials and construction
system configurations and components
control strategies

Selection of suitable WECS

Terminology
analysis of site load and wind speed / direction data
suggested WECS characteristics to suit site
selection of commercial WECS
analysis of commercial WECS energy output
optimising tower height
tower design, erection and survival requirements
system integration eg. with PV or gensets
selection of balance of system components
installed capital costs, life cycle costs

Installation, commissioning and maintenance

Regulatory requirements eg. planning approvals,
  environmental, heritage or cultural requirements
Liability
Mechanical:
  tower selection
  tower erection
  lightning protection
  maintenance
  safety
Electrical:
  transmission voltage and cable size,
  lightning and general circuit protection,
  balance of system components
  maintenance

	safety

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. A system design project may serve as the major assessment item.
Conditions of assessment	Normally learning and assessment will take place in a classroom or laboratory environment or in simulated or actual workplace conditions during installation, commissioning and maintenance work.

7. Learning outcome details

Learning outcome 1

Determine the characteristics of the major local winds including their direction, diurnal and seasonal patterns, as well as the influence of topography, surface roughness and temperature inversions.

Assessment criteria

1.1 Define these terms:

- weather charts
- isobars
- fronts and troughs
- cyclone and anti-cyclone
- atmospheric boundary layer
- geostrophic wind
- gradient wind
- wind shear
- wind rose
- roughness and displacement lengths

1.2 Describe the major global wind circulations and the formation of major wind flows over your continent.

1.3 Describe the major features of the atmospheric boundary layer including:

- variation of wind speed with height according to Logarithmic and Power Laws
- effects of surface roughness
- atmospheric stability & temperature inversions
- turbulence

1.4 Identify the major local winds including:

- trade winds
- sea and land breezes
- katabatic and anabatic winds

1.5 Examine the likely effects on the major local winds from local topography, surface roughness, isolated barriers and temperature inversions.

1.6 Describe typical diurnal, monthly and seasonal patterns of winds over the local area.

1.7 Describe the formation and likely effects of extreme winds and wind shear.

Learning Outcome 2	**Analyse wind speed and direction data from Bureau of Meteorology records and data logging anemometers.**
Assessment criteria	2.1 Define these terms: porosity internal boundary layer speed-up factor temperature inversion factor wind speed frequency distribution lull period calms
	2.2 Interpret local and regional wind speed and direction data such as local records (Eg. Meteorological Bureau data), ecological indicators and wind speed/energy maps.
	2.3 Measure wind speed and direction using data logging anemometers.
	2.4 Apply manufacturer's calibration curves for anemometers to correct recorded data.
	2.5 Calculate at a site monthly and yearly average wind speed , and wind power density from existing, nearby data or on-site measurements, , using appropriate software.
	2.6 Estimate the wind speed at a WECS tower of suitable height and location given: wind speed data recorded at two or more elevations at the site, wind speed data recorded at one elevation and appropriate surface roughness, temperature inversion and speed-up factors at the site.
Learning outcome 3	**Determine the suitability of a site for a WECS taking into consideration local topography, surface roughness, isolated barriers, temperature inversions, wind speed and direction data at the site.**
Assessment Criteria	3.1 Outline the likely effects of local topography, surface roughness, isolated barriers and temperature inversions on a WECS at a given site.
	3.2 Assess available local or regional wind speed, wind energy and direction data.

	3.3	Select the most appropriate site-monitoring location taking into consideration factors such as: Topography Accessibility Surface roughness Shielding from isolated barriers (obstacles) Turbulence Temperature inversions Power transmission distance Environmental and heritage impacts eg. noise, visual, bird life, national parks or aboriginal sites
	3.4	Measure wind speed and direction data at an appropriate site and height(s) using a data logging anemometer over a sufficient period of time.
	3.5	Analyse this recorded wind speed and direction data to determine if the site is suitable for wind energy utilisation.
Learning outcome 4	**Determine the suitability of a wind turbine for a particular application in terms of its characteristics and materials of construction.**	
Assessment Criteria	4.1	Describe the basic operation of lift and drag type WECS.
	4.2	Compare the characteristics of WECS in terms of power and torque, efficiency (power and output co-efficients), solidity and tip speed ratio.
	4.3	List the major categories and sub-categories of WECS.
	4.4	State the advantages and disadvantages of each type of WECS.
	4.5	Describe suitable materials for the construction of WECS taking into consideration fatigue stresses and environmental conditions such as salt air, humidity and Ice.
	4.6	Describe typical system configurations and components for: stand-alone power systems water pumping
	4.7	Describe strategies and/or mechanisms to control: mechanical stresses on the WECS in gale force winds power output for battery charging

	4.8 Select an appropriate type of WECS for a particular application.
Learning outcome 5	**Specify the size, characteristics and system configuration of a WECS that will provide a given WECS fraction to a load at a site with specified wind speed data according Australian Standard AS4509.**
Assessment criteria	5.1 Select suitable WECS specifications to suit site load and wind speed data according to AS4509 including: cut-in, rated and furling wind speeds blade diameter rated power at an appropriate rated wind speed materials of construction
	5.2 Select a suitable commercially available WECS that most closely fits the specifications outlined in 5.1.
	5.3 Assess suitable tower requirements at the site including site access, soil type and foundations, structural certification and planning approvals.
	5.4 Calculate the monthly and annual energy output of the selected WECS at the site from wind speed data and load data using appropriate computer software and in accordance with AS4509.
	5.5 Optimise the height of the tower and the size of the WECS.
	5.6 Select a suitable system configuration.
	5.7 Select balance of system components including: Battery storage Inverter Regulator Transmission cable Back-up battery charger and generator
	5.8 Assess the equipment reliability and manufacturer / suppliers back-up service including availability of spare parts and service personnel
	5.9 Calculate the installed capital and life cycle costs of various system configurations according to AS3595 and AS4536.

5.10 Examine environmental, cultural and social factors that impact on the implementation of a WECS such as:

- External costs,
- WECS manufacturing processes and embodied energy and energy payback time,
- Noise levels,
- Visual amenity
- RFI.

Learning outcome 6

Specify the installation and maintenance requirements for a chosen WECS at a site in accordance with AS4509.

Assessment criteria

6.1 Select an appropriate tower for the installation of a WECS taking into consideration:

- soil type and footings
- local council approvals
- appropriate codes such as AS1170.2
- transport of tower

6.2 Demonstrate appropriate methods, using appropriate safety procedures, for :

- Raising tower and WECS,
- lightning protection,
- tower maintenance,
- safety in the erection and maintenance of the tower and WECS,
- site management to minimise environmental impacts.

6.3 Select an appropriate electrical transmission voltage and cable size from the WECS to the load or energy storage.

6.4 Demonstrate appropriate installation, commissioning, faulty diagnosis and rectification, and maintenance methods using appropriate safety procedures. This will include:

- WECS power output
- Voltage regulation
- Transmission cable voltage drop
- Manual and automatic furling
- Shut-down

6.5 Draw schematic and wiring diagrams for the WECS showing the general circuit layout and protection between the WECS, energy storage, inverter and loads according to AS3000, AS4509 and lightning protection requirements.

6.6 Draw a suitable layout for the location of energy storage to meet AS 3000, AS 3011.1 and AS4509.

6.7	Describe safety procedures for the installation, commissioning, fault diagnosis and maintenance of system components.
6.8	Prepare a maintenance schedule for the system.

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 experiments 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. 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.

In the delivery of this module, the following Occupational Health and Safety issues are to be addressed in the appropriate learning outcome(s):

General:

- lifting and carrying
- eye/skin/ear protection
- use of power tools
- climbing eg ladders/towers and WECS to avoid injury due to falls and blade rotation, WECS yawing, falling objects such as tools.
- keeping work areas tidy
- rigging procedures for WECS and towers
- handling acid and toxic chemicals

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	Two (2) data logging anemometers Mast-to-mount anemometers, Computer software for analysis of wind speed and direction data and assessment WECS monthly and annual energy output, Small wind turbine (recommended 1.5 to 3 metre blade diameter) and voltage regulator typical of current market products, Access to a suitable battery storage facility and load dumps, A suitable tower and site to mount the WECS on to undertake measurements of WECS performance. If this is a permanent installation, a minimum tower height of about 18 metres is recommended. Alternatively, this work may be able to be conducted using a temporary structure mounted on a vehicle such as a utility, and drive to a suitable site. Appropriate metering to measure the WECS instantaneous power output and energy output over time. Appropriate meters, tools and safety equipment to undertake installation, commissioning and maintenance.
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