## 1.Module details

**Module name**

### Micro-hydro Systems

**Module duration**

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

**Module code**

NUER05

**Discipline code**

1105

## 2. Module purpose

This module provides training in the design, application, installation and maintenance of micro hydro energy systems.

It combines both theory and its applications to stand-alone power systems for residential and small community systems.

## 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 Electro-technology Competency Standards, namely NES113, NES219, NES305, NES412, NES506, NES710.

## 5. Content

**Site evaluation**

terminology
measurement of head .
measurement of flow rate.
map reading
local rainfall and catchment data
load estimation
regulatory requirements

**System components and configurations**

turbine types
turbine components
typical system configurations
operational characteristics
non electric systems

**System design**

analysis of site data and energy demand
application of energy efficiency measures
commercial turbine selection

dams, weirs, watercourses and penstocks, strainer and intake systems
pipe frictional losses
balance of system components

**System installation and maintenance**

mechanical: turbine mounting, dam/weir construction, penstock installation, water outlet construction
electrical: transmission voltage, cables, lighting and general circuit protection, battery room design
maintenance and safety

**System costing**

capital costs
life cycle costs

## 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/ laboratory environment, or in simulated or actual workplace conditions during installation, commissioning and maintenance work.

## 7. Learning outcome details

**Learning outcome 1**

**Evaluate the suitability of a site for use of a micro hydro energy system.**

**Assessment criteria**

1.1 Define these terms:
- potential and kinetic energy
- gross head
- net head
- flow rate

1.2 Measure the available head at a site using a dumpy level or theodolite, altimeter, pressure gauge and contour maps.

1.3 Compare the accuracy, advantages and disadvantages of each method for flow and head assessment.

1.4 Measure the flow rate of a given site using each of the following methods - catchment area calculations, water diversion to fill a container, stream velocity/area measurement and/or weir construction method.

1.5 State the advantages and disadvantages of each method of head and flow measurement with particular reference to their accuracy.

1.6 Estimate the long term usable flow rate from long term stream flow if available able taking into account environmental considerations.

1.7 Identify the effects of seasonal variation using long term weather data.

1.8 Calculate the typical daily and seasonal energy consumption profile at a given site.

1.9 Describe the effect of the energy demand profile both daily and seasonally at the site on the system sizing.

1.10 Identify government regulatory requirements such as those covered under environmental or water resource legislation.

1.11 Identify environmental constraints at a site including minimum stream flow rates, ecological impacts, visual and noise impacts.

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| **Learning outcome 2** | **Determine the suitability of a micro hydro energy system for a particular application in terms of its characteristics and the application.** |
| **Assessment criteria** | 2.1 Describe the structural differences between the Pelton, Turbo Impulse, Francis, propeller type, Michell or Banki cross flow turbines and PATS (Pumps As Turbines). |
| | 2.2 Show the system configuration for each turbine type identifying all major components. |
| | 2.3 For impulse and cross flow turbine types, compare bucket and blade shapes, nozzle shapes and types, types of hydraulic and electrical controllers/governors, speed increasers and overspeed clutches and their basic operation and appropriate application. |
| | 2.4 Compare the operational parameters and efficiency of different turbines. |
| | 2.5 Describe the circumstances under which battery storage would be used. |
| | 2.6 Outline the respective merits and suitability of various turbine types for various micro hydro-electric applications. |
| | 2.7 Describe the operation of hydraulic rams or similar water pumps. |
| | 2.8 Outline typical efficiencies of hydraulic ram systems and appropriate applications. |
| | 2.9 Compare the advantages and disadvantages of water energy storage systems with other energy storage systems such as battery banks. |
| **Learning outcome 3** | **Specify the size, characteristics and system configuration for a micro hydro energy system which will provide a given load at a site with specific head and water flow rate data.** |
| **Assessment Criteria** | 3.1 Select suitable MHS characteristics to suit site load, hydraulic head and stream flow rate characteristics. |
| | 3.2 Select a suitable type of commercially available MHS to suit 3.1. |
| | 3.3 Calculate frictional losses in delivery pipes using manufacturer's data. |

3.4 Calculate the energy output of the selected MHS at the site from water flow rate, head and manufacturer's data, allowing for seasonal variations in performance and environmental constraints.

3.5 Describe the design of any required weirs or dams, open races or penstocks, strainer and intake systems.

3.6 Optimise the positioning of the MHS and size of the MHS.

3.7 Select suitable balance of system components including delivery pipe and fittings, transmission cable and voltage, voltage and frequency regulation, battery storage type and capacity, battery charger, inverter, back-up generator, and load dump.

3.8 Outline likely environmental impacts of the MHS and appropriate measures to minimise these impacts.

**Learning outcome 4**

**Specify the installation, commissioning and maintenance requirements for a chosen micro hydro system at a site.**

**Assessment Criteria**

4.1 Select an appropriate MHS taking into account the topology of the site, local council approvals, environmental considerations, site access and transport of equipment, water and power transmission distances and daily and seasonal load profiles.

4.2 Outline appropriate methods, using appropriate safety procedures, for:

dam or weir construction;

watercourse construction and/or penstock installation; turbine installation;

4.3 Demonstrate appropriate installation, commissioning, fault diagnosis and rectification procedures and maintenance methods using appropriate safety procedures.

4.4 Prepare a maintenance schedule for the system.

4.5 Draw schematic and wiring diagrams for the MHS showing the general circuit layout and protection between the MHS, batteries, inverter and loads according to Australian Standards AS3000, AS4509, and AS4086.2 requirements.

4.6 Describe safety procedures for the installation, commissioning, fault diagnosis and maintenance of system components.

**Learning outcome 5**

**Determine the most cost effective option for a micro hydro energy system including the cost of site works and all installed equipment, by undertaking a life cycle costing according to Australian Standards AS 3595 and AS 4536. .**

**Assessment criteria**

5.1 Describe the major costs to be considered in the life cycle costing method.

5.2 Calculate the capital and life cycle cost that includes the cost of various system configurations for a micro hydro application.

5.3 Examine external costs that might impact on the cost effectiveness of a MHS.

5.4 Select the most cost effective of a number of options on the basis of life cycle costing analysis.

## 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. 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 in or around streams and in steep rocky country
- keeping work areas tidy

Electrical:

- use of measuring meters
- isolation procedures
- use of ladders
- work with battery installations (Eg. hydrogen explosion, acid spillage, ventilation, short circuits)

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| **Minimum physical resources** | Computer software suitable to analyse the performance and life cycle cost of micro hydro energy systems.<br><br>Flow channel with suitable pump, flow meter, V notch, trapezoidal or rectangular dams (or on site equivalent).<br><br>A class set of tripods and dumpy levels, surveyor's poles, plastic floats, surveying pegs, tape measures, stop watch, container, hose and pressure gauge.<br><br>Small hydro-electric turbine (up to 1 kV A) and controller with appropriate pressurised water supply .<br><br>A suitable battery bank or loads to be provided with power from the MHS. |

**Recommended References**


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

European Small Hydro Power Association (2000) *Layman's Guidebook on how to Develop a Small Hydro Site* Commission of the European Communities. Directorate General For Energy

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Fraenkel, P. et al (1991) *Micro-Hydro Power – A Guide for Development Workers*. IT Power & Stockholm Enviro Institute

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Inversin, A.R. (1986) *Micro-Hydropower Sourcebook – A Practical Guide to Design and Implementation in Developing Countries.* NRECA International Foundation

Pedals, P. (1996) 9th Edition. *Energy from Nature.* Rainbow Power Company.

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

Micro Hydro power BasicsClan Web:- www.geocities.com/wim_klunne/hydro

Small Hydropower Handbook-A guide to Understanding and constructing your own Small hydro Project. Web:- www.smallhydropower.com/manual3.html