Unit 301: Understand the fundamental principles and requirements of environmental technology systems

# Handout 7: Micro-hydro

## Learning outcomes

The learner will:

1. Know the fundamental working principles of micro-renewable energy and water conservation technologies.
2. Know the fundamental requirements of building location/building features for the potential to install micro-renewable energy and water conservation systems to exist.
3. Know the fundamental regulatory requirements relating to micro-renewable energy and water conservation technologies.
4. Know the typical advantages and disadvantages associated with micro-renewable energy and water conservation technologies.

## Assessment criteria

The learner can:

* 1. Identify the fundamental working principles for each of the following heat producing micro-renewable energy technologies: micro-hydro.

2.7 Clarify the fundamental requirements for the potential to install a micro hydro system to exist.

3.1 Confirm what would be typically classified as ‘permitted development’ under town and country planning regulations in relation to the deployment of the following technologies: micro-hydro.

3.2 Confirm which sections of the current building regulations/building standards apply in relation to the deployment of the following technologies: micro-hydro.

4.1 Identify typical advantages associated with each of the following technologies: micro-hydro.

4.2 Identify typical disadvantages associated with each of the following technologies: micro-hydro.

## Micro-hydro

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| Small-scale hydropower is one of the most cost-effective and reliable energy technologies to be considered for providing clean electricity generation.  Running water can be used to generate electricity, whether it's a small stream or a larger river.  Small or micro hydroelectricity systems, also called hydropower systems or just hydro systems, can produce enough electricity for lighting and electrical appliances in an average home. |  |

All streams and rivers flow downhill. Before the water flows down the hill, it has potential energy because of its height. Hydropower systems convert this potential energy into kinetic energy in a turbine, which drives a generator to produce electricity. The greater the height and the more water flows through the turbine, the more electricity is generated.

## How they work

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| Most micro‑hydro systems are ‘run of river’ that is, they use the natural flow and fall (or head) of the watercourse to drive the turbines.  The alternative is to dam the watercourse to artificially raise the head and control the flow; these systems are only really viable on large commercial systems.   * Water is taken from the river by diverting it through an intake at a weir. * In medium or high-head installations water may first be carried horizontally to the forebay tank by a small canal or ‘leat’. * Before descending to the turbine, the water passes through a settling tank or ‘forebay’ in which the water is slowed down sufficiently for suspended particles to settle out. |  |

* The forebay is usually protected by a rack of metal bars (a trash rack), which filters out water-borne debris.
* A pressure pipe, or ‘penstock’, conveys the water from the forebay to the turbine, which is enclosed in the powerhouse together with the generator and control equipment.
* After leaving the turbine, the water discharges down a ‘tailrace’ canal back into the river.

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| Installation location Hydropower is very site specific. Most homes will not have access to a suitable resource even if they have a water course running nearby. Assessing a hydro site properly is a job for a professional.  To be suitable for electricity generation, a river needs to have a combination of:   * **flow** – how much water is flowing down the water course per second, and * **head** – available vertical fall in the water, from the upstream level to the downstream level.   It is generally better to have more head than more flow, since this keeps the equipment smaller.  Sites where the gross head is less than 10m would normally be classed as ‘low head’. From 10-50m would typically be called ‘medium head’. Above 50m would be classed as ‘high head. |  |

The flow rate is the volume of water passing per second, measured in m3/second. For small schemes, the flow rate may also be expressed in litres/second where 1000 litres/second is equal to 1m3/second.

Hydro-turbines convert water pressure into mechanical shaft power, which can be used to drive an electricity generator, or other machinery. The power available is proportional to the product of head and flow rate.

The general formula for micro‑hydro system’s power output is:

Where:

**P** is the mechanical power produced at the turbine shaft (Watts),

**η** is the hydraulic efficiency of the turbine, (expressed as a decimal)

**g** is the acceleration due to gravity (9.81m/s2),

**Q** is the volume flow rate passing through the turbine (litres/second),

**H** is the effective pressure head of water across the turbine (m).

The best turbines can have hydraulic efficiencies in the range 80 to over 90% (higher than all other prime movers), although this will reduce with size. Micro-hydro systems (5 ‑ 100kW) tend to be 60 to 80% efficient.

## Example 1

A micro‑hydro system has a flow rate of 20 litres/second passing through the turbine fed from an effective head of 10 metres. The effective efficiency of the turbine is 60%. Calculate the mechanical power produced at the turbine shaft.

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It must be noted that the electrical generator itself will not be 100% efficient so the available electrical power will be less than the figure calculated above. In example 1 above, if the electrical generator had an efficiency of 70%, the electrical power generated would be:

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## Using the electricity

It is important to determine at the outset what the value of the electricity generated by the installation will be, i.e. to whom the power will be sold.

The electricity generated by an installation may be used at the point of generation, in place of or to supplement electricity supplied by the local electricity company. Alternatively it may be exported via the local distribution network by agreement with the Distribution Network Operator (DNO).

It is nearly always financially advantageous to consume as much of the power as possible on site, and only export the surplus into the network.

If the installation is to produce power for export to the local network, there should be early discussions with the DNO who will specify the system protection and metering equipment, and will also provide an estimate of connection costs and the best location for feeding into their system.

Feed-in Tariffs (FITs), available since April 2010 to reward renewable electricity generation, provide a further incentive but installers must consider issues such as protecting wildlife and fish - which may mean including additional features in the installation design.

## Planning requirements

All new hydroelectric systems require planning permission and an abstraction licence.

If you are planning to remove or abstract more than 20m3 (20,000 litres or approximately 4,400 gallons) of water per day from a watercourse you will need an ***abstraction licence***, even if the water is later put back into the watercourse. This means that virtually all micro hydro projects will require such a license, as even a flow rate of 1 litre per second amounts to 86m2 per day.

The license must be sought from the Environment Agency, who will assess effects on river ecology and flooding, prior to installation. The Environment Agency recommends that you contact them as early as possible as it can take around 3 months to get the license. For further information, consult the Environment Agency's document *‘Abstracting water - A guide to getting your licence’*.

It's also worth discussing details with local planning officials, as the powerhouse and pipe work may require planning permission.

If you don't own the land involved you'll need to seek permission from the landowners.

## Building Regulations requirements

Any building works, eg the power/turbine house will require, apart from planning permission, the appropriate parts of Building Regulations.

## Advantages of micro‑hydro

* Efficient energy source
* A hydro system can generate 24 hours a day, often generating all the electricity the consumer needs and more.
* Reliable electricity source; hydro produces a continuous supply of electrical energy in comparison to other small-scale renewable technologies. The peak energy season is during the winter months when large quantities of electricity are required.
* If eligible, the consumer will get payments from the feed in tariff for all the electricity generated, as well as for any surplus electricity sold back to the grid.
* Hydroelectricity is green, renewable energy and doesn't release any harmful carbon dioxide or other pollutants.
* No reservoir for ‘run of river’ installations required.

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| Disadvantages of micro‑hydro  * Large initial capital outlay * Suitable site characteristics required * Energy expansion not possible; the size and flow of small streams may restrict future site expansion as the power demand increases. * Low-power in the summer months * Environmental impact |  |