HIenergy
HIGHLANDS AND ISLANDS OF SCOTLAND
HARNESSING NATURE'S POWER

Factsheet

Hydro Energy


Image Courtesy of npower renewables


Image Courtesy of Dulas Ltd

Hydroelectric schemes are the biggest contributor of electricity from renewable sources worldwide. Scotland's wet climate and mountainous terrain means that as a country we are well placed to make use of the technology. Currently around 12% of our electricity is produced from hydropower.

The majority of Scotland's hydro stations are based around the use of a dam and storage reservoir and can be classified as large scale.

Significant potential also exists in the country for development at a smaller scale. A briefing by the Scottish Renewables Forum in 2006 estimated that a further 500MW of new Scottish micro hydro sites could be developed given the right support.

In the Highlands and Islands there are likely to be two types of site which are particularly worthy of consideration for development:

Historic Water Mills
Water was once used extensively to power many of Scotland's old mills. Some estimates put the number of old mill sites in the UK as high as 20,000. A major advantage of these sites is that it is often possible to reuse some of the existing civil structures such as the weir and the leat, thereby reducing the cost of the installation.

Hilly Areas with Spring-Fed Streams
In addition to historic sites, considerable potential exists in many hilly areas of Scotland for micro hydro power. Turbines are available which can utilise quite small spring fed streams for power generation if the fall is sufficient. These sites can often be developed at reasonable cost since civil structures associated with large flows of water, such as weirs, are not required. (HydroGeneration Ltd)

Schemes built at such a scale offer many benefits; they are highly efficient (typically around 60%) and can remain in operation for around 50 years. As most schemes of this type are 'run of the river' (ie designed without a dam or barrage in place) they also avoid the adverse effect on the environment associated with large scale hydro projects.

If you require further information, please contact the renewable energy team at Highlands and Islands Enterprise
Tel: **01463 244350** Email: **renewables@hient.co.uk**

Hydro Energy

Components of a Small Scale Hydro Scheme

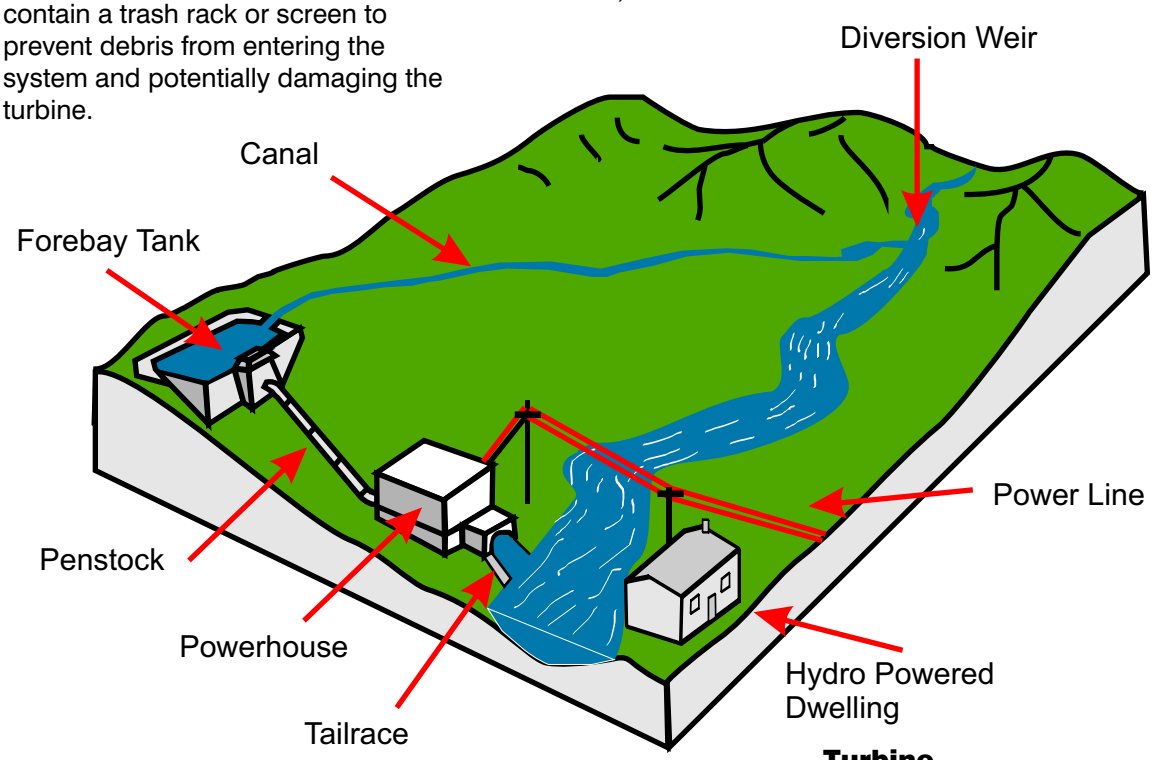
A typical run of the river hydro scheme will consist of the following components. Other configurations can be used depending on the topographical and hydrological conditions, but all adopt the same general principle.

Diversion Weir (Intake)
The diversion weir is generally the highest point of any hydro system. It is used to divert water away from its natural course for feeding into the penstock. The weir itself may contain a trash rack or screen to prevent debris from entering the system and potentially damaging the turbine.

Canal
The manmade channel which carries the water from the intake weir can have several names. It is also known as the headrace, lade or leat.

Forebay Tank
The forebay tank allows debris to be separated from the water that enters it via the canal before it enters the penstock

Penstock
The penstock (sometimes called a pipeline) is a pipe generally made from steel or high strength plastic. Its job is to deliver the water to the turbine under pressure.

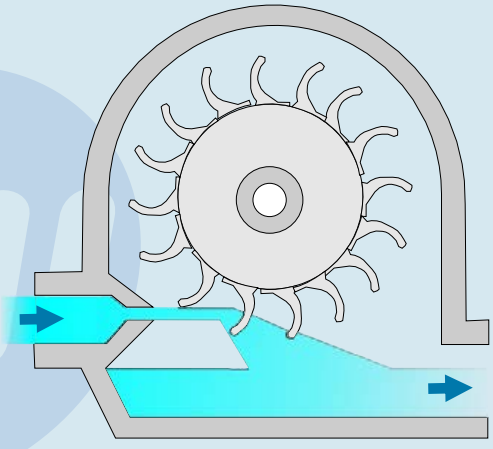


Tailrace
Having passed through the powerhouse the water is then returned to the original watercourse via a man made channel known as the tailrace.

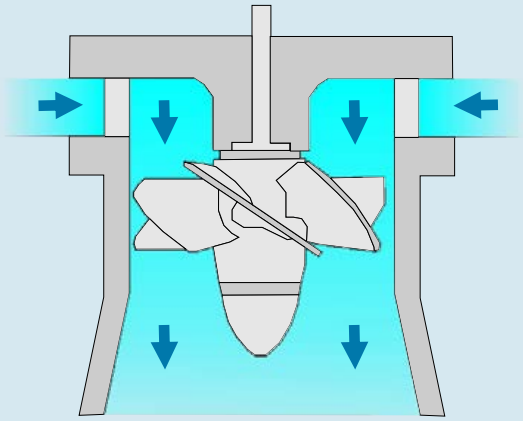
Powerhouse
The powerhouse is the enclosure at the bottom of the system that contains the turbine, generator and all controls. Its main function is to provide a safe environment for the system components and protect them from the elements.

Generator
The generator converts the rotational energy from the turbine shaft into electricity.

Turbine
The turbine is the heart of the system, where the power contained in the now pressurized water is converted into mechanical shaft power. There are two main types of turbines; Impulse and Reaction. Impulse and Reaction turbines are typically used at high and low to medium head sites respectively. The major difference between an impulse and reaction turbine is that in a reaction turbine there is no free jet water and it must run full of water (See below)



An Impulse Turbine



A Reaction Turbine

Hydro Energy
Considerations

Capital Costs
Even without a dam or reservoir (as is the case with most micro hydro schemes) any project is likely to have high initial capital cost due to the costs associated with infrastructure. This high initial cost is however mitigated by the long lifetime, high reliability and availability of plant, low running costs and no annual fuel costs.

According to the head of a site, hydro schemes can be classified into three categories:

- High head: 50m and above
- Medium head: 10 - 50m
- Low head: under 10m

Perhaps more so than any other renewable energy technology costs associated with hydroelectricity are incredibly site dependent. For example penstocks can vary in length between a few metres to over a kilometre on a site to site basis. Proximity to the national grid will also affect the economics greatly (assuming you are looking to connect to it)

The Energy Savings Trust provides the following indicative costs for such schemes;

For low head systems (not including the civil works so assuming there is an existing pond or weir), costs may be in the region of £4,000 per kW installed up to about 10kW, and would drop per kW for larger schemes.

For medium heads, a fixed cost of about £10,000, and then about £2,500 per kW up to around 10kW - so a typical 5kW scheme might cost £20-£25,000. Unit costs drop for larger schemes.

Payback
As the costs associated with the installation of hydro plant vary greatly from site to site, typical payback times are hard to quantify. One benefit affecting payback which is constant with all hydro schemes is that the electricity generated qualifies for ROCs (Renewable Obligation Certificates). Over the lifetime of a project this can potentially improve the economics greatly.

Maintenance
The most pertinent maintenance consideration of a small or micro hydro scheme involves the cleaning of the trash rack on a periodic basis. Checks of the turbine and the internal workings of the powerhouse should be conducted relatively frequently for the first few years to ensure it is set up correctly and then annually by a suitably qualified individual.

Planning Permission
Installing a hydroelectric scheme could have major implications for the river it is situated on and its surrounding environment. The development of any scheme should be done in a manner which is harmonious with the many other uses to which the river is put. Early consultation with local planning authorities, Scottish National Heritage (SNH), the Scottish Environmental Protection Agency (SEPA) and the local District Salmon Fishery Board (DSFB) is essential to ensure that the proposal would not detract from the existing value and interest of the watercourse and its surroundings.

Generally speaking there are three licences that may be required before any scheme can get the go ahead:

- Abstraction Licence - required if water is being permanently or temporarily removed from a water source;
- Impoundment Licence - required if changes are being made to structures which impound water, such as weirs and sluices;
- Land Drainage Consent - required for any works being carried out in a 'main channel'.

SEPA can advise on which licences will be required to operate your scheme.

The installation and deployment of crossflow turbines at two former mill sites
Images Courtesy of HydroGeneration Ltd

Hydro Energy
Step by Step

If you think you may have a suitable site for hydro generation there are several initial checks you can make yourself.

The British Hydropower Association outlines the following three areas that require investigation during the early stages of assessing a hydro project.

Potential Resource
Initially the most important facet is to quantify the potential energy resource. This will dictate whether or not any project is worth taking forward. This involves estimating or measuring the available head and flow, then calculating what the annual energy capture of the scheme would be.

Calculating Head
The head of water available at any site can be determined by measuring the height difference between the water surface at the proposed intake and the river level at the point where the water will be returned. This is most commonly done using surveyor tools such as theodolites or sight levels. Initial measurements can be taken with a GPS.
It is very important to measure head accurately. The gross head of a site not only affects power, but will also determine the type of turbine to use.

Calculating Flow
Water levels change through the seasons so it is important to measure flow at various times throughout the year. Three popular methods are used for measuring flow - container, float, and weir.

All three methods are illustrated opposite. The container method is likely to be the easiest method for measuring flow at a micro hydro site although it may require building a temporary dam.

The guides cited in the *Useful Links* section provide a more detailed methodology of how to go about measuring head and flow.

Permissions
If the potential output of a scheme is attractive, you need to be sure that all relevant permissions will be granted for using the land required to develop the scheme and to have the necessary access to it. Contact with surrounding landowners should therefore be made at an early stage.

All water courses in Scotland are controlled by SEPA. To remove water from them will almost certainly require their permission in the form of a licence. They should be contacted regarding the costs associated with obtaining this license and can advise on all other environmental aspects of riverside development.

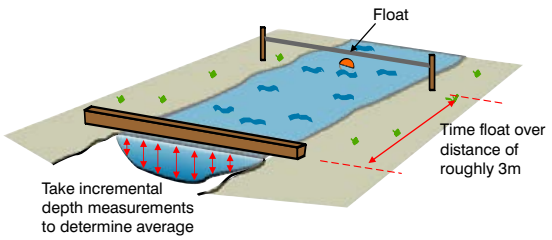
Power Destination
Finally, there needs to be a clear destination for the power: is there a nearby load that can be supplied with power from the scheme, or is there a convenient point of connection into the local distribution network?

Next Steps
If you feel that a potential scheme may exist the next step would be to seek professional help. A renewable energy consultant can be employed to conduct a pre-feasibility study which would examine the prospects of your scheme in more detail. Such a study may include the following:

- Hydrological Survey
- Environmental Assessment
- System Design
- System Costing
- Potential Energy Output
- Outline of Revenue Generation Options

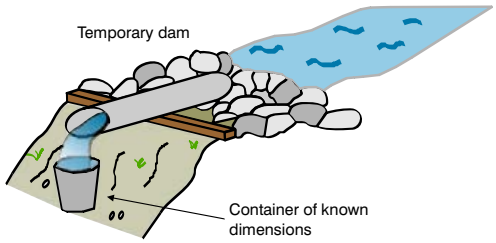
Float Method

The float method is useful for large streams if you can locate a section of about 3m long where the stream is fairly consistent in width and depth.



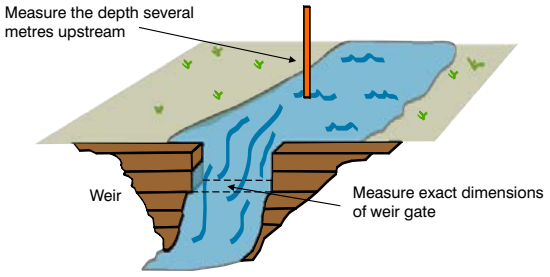
Container Method

The container method should be used at a location along a stream where all the water can be caught in a container. If such a spot does not exist, investigate the practicalities of constructing a temporary dam



Weir Method

Using a weir is the most accurate method of flow measurement. All water is directed through an area that is exactly rectangular making it easy to measure the height and width of the water to calculate flow.



Useful **Links**

British Hydropower Association's Mini Hydro Guide
www.british-hydro.org/mini-hydro/index.asp

A Layman's Guide to Small Hydro Schemes in Scotland
www.hi-energy.org.uk/documents/Laymans%20Guide%20to%20Hydro.pdf

The National River Flow Archive (contains flow data from 1300 gauging stations across the UK)
www.ceh.ac.uk/data/nrfa/index.html

A comprehensive list of accredited manufacturers and installers of hydro equipment can be found here
www.lowcarbonbuildings.org.uk/info/installers

The Energy Saving Trust - Small Scale Hydro
www.est.org.uk/myhome/generating/types/hydro