DARE

The Devon Association for Renewable Energy

FACTSHEET 5: Introduction to Micro Hydro Power

Introduction

Hydroelectricity is the conversion of energy from flowing water into its more useful form – electricity. Flowing water turns a turbine, which in turn converts this energy to electricity. Where traditional water wheels use the power of falling water to work milling equipment, modern hydro-turbines use this power to create electricity.

A good micro-hydro scheme will be designed to operate with minimal environmental impact with a degree of automatic control to offer low running costs and high reliability over a long life. The 'power' available in a river relates directly to the work done by the weight of water as it falls through a vertical distance under the acceleration of gravity – i.e. a function of the product of 'head' and 'flow'. The 'electrical' power output has to take regard of the efficiencies of the turbine and generator.

1. Head

The 'head' is the vertical distance that the water falls on the available section of waterway, measured in metres. This can be worked out by looking at OS maps, measuring with a board and spirit level, or using a surveyor's theodolite. It is also worth considering if you can co-operate with neighbouring landowners to access additional height.

FIGURE 1: TYPICAL SITE WITH LOW HEAD POTENTIAL

2. Flow

The gross annual flow in a river is the product of the size of the catchment x the annual rainfall less any water that is removed from the catchment by way of evaporation, transpiration, or by agricultural or Industrial abstractions. A certain minimum volume of water, known as the 'residual flow' must be left in the river to protect the ecology of the river species. The flow potentially available for hydropower is that left after all other priorities are satisfied. Since rainfall is seasonal, the daily flow rate should be recorded over 12 months to determine the 'Flow Distribution Curve' and the 'mean annual flow' (m^3/s) for the proposed site. The Environment Agency will state what residual flow must be left and authorise what flow can be used for hydropower.

3. Assessing a site for micro-hydro potential

Micro-hydro schemes are generally classified as either – high or low head sites. Low head sites will include old mills and weirs, with a head of around 1-4m. To achieve a reasonable power output either the 'head' or the 'flow' needs to be of significant value. Of the two, a high head is preferred as it is more likely to offer a shorter payback period. Low head sites, particularly where there is some existing civil infrastructure, can still offer a good return if a large enough flow is present. High head sites will typically be steep fast flowing upland streams and rivers, where though the flow is low a high head can easily be achieved. These sites will generally be without any previous hydropower development but are still well worth investigating.

'Best Practice' dictates that designs without stored water (i.e. dams) should be based on the lowest flow parameters – a turbine designed to accommodate large winter flow rates (expensive) may otherwise lie idle for months with insufficient water to operate it in the summer. Designing for low summer flow rates will require a smaller, cheaper, turbine that is more likely to operate for most of the year.

To determine a 'first estimate' of the potential electrical power available for a site you need to use summer flow figures and apply the formula: Power (kW) = 5 x Head (m) x Flow (m^3/s). Multiplying this answer by the number of hours this flow is available during the year will give an indication of the annual energy output in kWh.

The 'first estimate' figure should allow a potential developer to decide whether to continue with further investigation or not. There is no hard and fast rule of what size site is economically viable. Generally the cost of an 'Abstraction Licence' and 'Land drainage Consents' are similar irrespective of site size, so the cost to the smaller site is disproportionately large. However a remote off grid site may find it cheaper to go through the licensing process than pay for a grid connection. Also the costs of employing a professional hydro engineering company may make the smaller site prohibitively expensive. Generally sites with above 10kW-installed capacity may be economic for professional development.

Sites below 2kW installed capacity may be suitable for DIY. Sites between 2 –10kW pose a difficulty, as there may be enough flow to be potentially dangerous if a weir were to fail and cause a risk of flooding downstream yet may not generate enough value to justify the use of professional consultants. Great care needs be exercised if considering a DIY scheme.

In addition to information about micro-hydro sites on Dartmoor, the 'Dartmoor Hydropower Survey' produced by DARE contains a wealth of generic information about hydro power that is applicable anywhere.

FIGURE 2: MORE LOW HEAD POTENTIAL

4. Environmental issues

All hydro schemes have an environmental impact. Water is abstracted from the main stream and diverted through a turbine before being returned to the main flow. During this stretch the flow in the main stream is depleted which could adversely affect bio-diversity – because of this the amount of flow that can be taken from the flow will be regulated in order to leave an acceptable base 'residual' flow level. The Environment Agency has a statutory duty to maintain the health of the river and protect the interests of existing lawful water users. Any hydro scheme will need to hold an 'Abstraction Licence', controlled by the nearest Government Office of the South West – such licenses could take up to 6 months to get.

Turbines are not 'fish friendly' so adequate screening both up and down stream has to be provided to stop fish and fry entering the turbine. Where migratory fish exist in a river, a fish ladder must be installed to enable fish to complete their journey upstream. However a well-designed hydro scheme will mitigate any environment damage caused during construction and over time will generate 'clean' energy for many years.

5. Grid connection

Micro-hydro systems can be grid connected or stand-alone. In an off grid system the power is used to charge a bank of batteries to collect the power, meaning that power will always be available. A back up generator might also be necessary for installations like these, to provide emergency cover to back up for seasonal variations in water flow. The batteries can be used to power low voltage DC appliances, or used with an inverter to convert the power to more conventional 240 volt alternating current (AC). A charge controller is also required in order to ensure that the batteries are not over charged, and when the batteries are full to divert electricity to other useful sources such as space or water heaters.

In sites that are connected to the grid the power will be fed through an inverter back into the grid, and a two way meter will measure power exported to the grid, and power imported from the grid. If the scheme produces more electricity than a site uses, then substantial profits can be made by selling back into the grid, and this will further help the economics of a site.

6. Costs

Considerable micro-hydro potential exists in many hilly areas. The initial costs will be quite high, but with hydro sites having the potential to run indefinitely, they represent a medium to long-term investment that can prove very cost effective. Sites will require periodic component replacements, e.g. a new generator every 10-15 years and new turbine approximately every 25 years, but with this maintenance they can produce clean, green electricity indefinitely. This electricity can then be used, offsetting the cost of buying in electrical power, and any excess power can be sold back into the grid, often generating significant incomes – all this helps offset the cost of installations and pay back the original investment.

Micro-hydro costs are very site specific, and can vary between £1000-£4500 per installed kW subject to the amount of civil engineering required. A 10 kW site may cost between £10,000 and £45,000 to develop, but if available for 8000 hours per annum could generate 80,000 kWh. At a sale price of 6p/kWh this would equate to an income of about £4800 per year, or offset a substantial amount of 'bought in' electricity. In addition such a scheme would (at the time of writing – January 2005) qualify to sell 'Renewable Obligation Certificates' (ROC's) (80 x £30 = £2400) offering a possible combined income of £7200/yr. In this example a scheme could pay for itself in 6.25 years.

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