Introduction

The use of falling or moving water to provide energy has a long history and the horizontal axis geared water wheel, of which there may have been 40,000 in the UK at one time, was so successful that it became the main source of mechanical power in much of the world.

In recent years there has been a growing interest in small-scale hydro for business and domestic users. The size of river required for a small-scale hydro-power scheme is surprisingly small, with suitable sites, ranging from small streams in hilly areas to former mill sites and larger rivers. The technology is mature and reliable and the key issue is often whether the costs of civil and electrical works will allow a financially viable scheme.

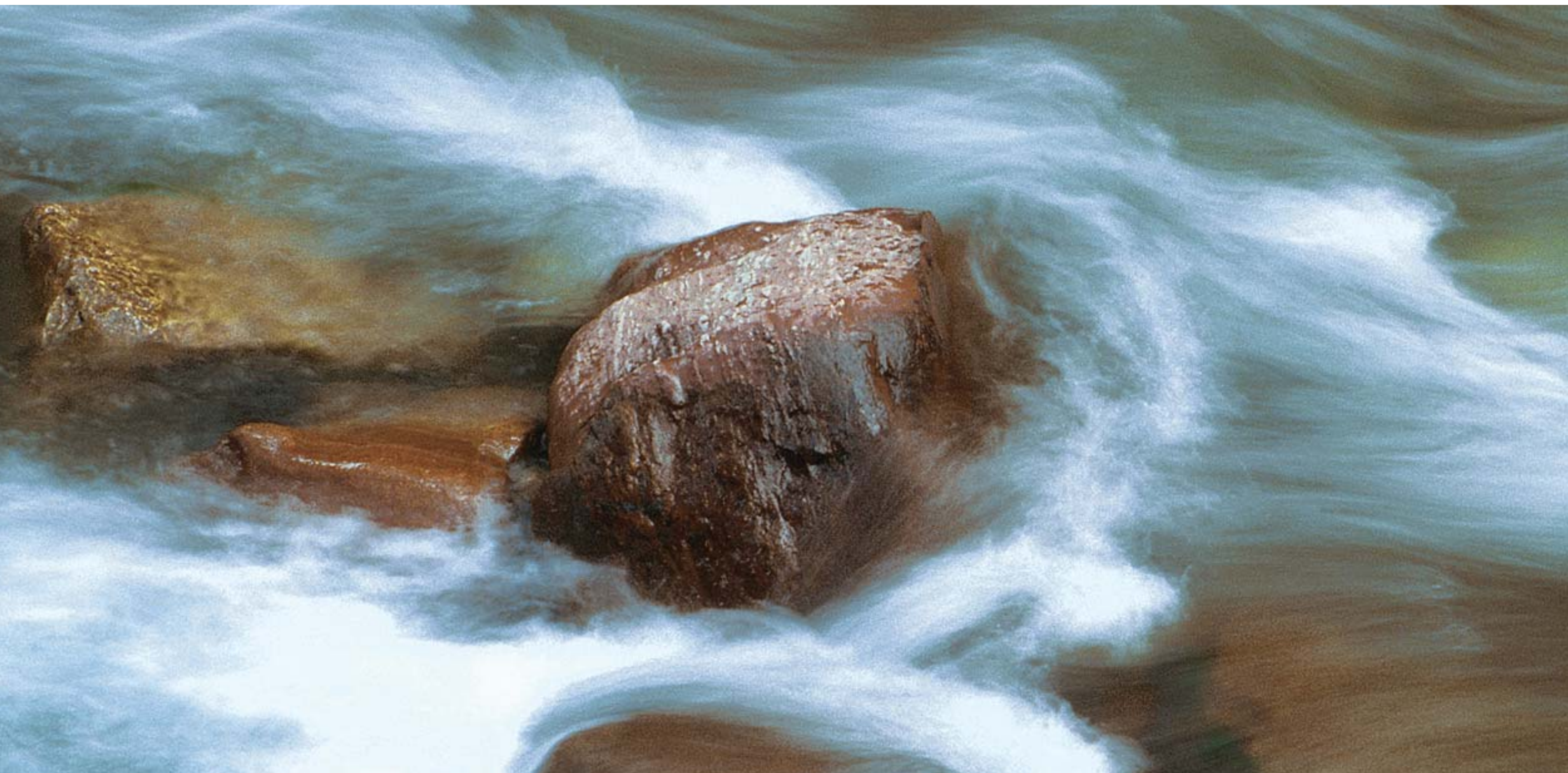
South West Resource

All of the feasible sites for large hydroelectric schemes in the South West have been exploited so that it is likely that remaining potential in the region will be for small scale, run of river sites up to a power rating of 100 kW. The REvision 2010 report estimated that there were around 100 small scale sites in the South West that could be developed totalling 20 MW.

Technology

Example Systems

Small-scale hydropower schemes come in a great variety of designs depending on the size of the river and the size of the load. Schemes can supply a single house, a community, a school or business, and are often 'grid connected' allowing electricity to be exported to the national grid. The smallest commercial systems are around 600W, sufficient to provide most of the electricity for a house. Larger schemes are capable of meeting the requirements of almost any commercial or local authority building.



Water Power Technology

Photo 1.
Sluice Gate controlling flow to turbine

All hydropower schemes require a flow of water and a height difference between the top of the scheme and the turbine. The larger the flow of water and the greater this height difference (known as the head) the more electricity will be generated.

The geography of the location usually determines the type of hydro power system that is most suitable - this can be a 'run of river' scheme or a 'storage' scheme incorporating a dam or reservoir.

A run of river scheme does not stop the river flow, but instead diverts part of the flow into a pipe (known as the penstock) and then through a turbine. These systems may not be able to generate during dry periods when a 'reserve' or 'residual' flow must remain in the watercourse.

Storage schemes involve building a dam to help ensure a constant supply of water and increased reliability - however these tend to be more expensive to construct and can have a significant impact on the down stream flow patterns of the river.

A large-scale hydro plant may be rated at 100,000 kW but a typical small-scale scheme might only be 10 kW. This implies that if micro-hydro were to play a sizeable role within a national energy strategy to reduce carbon emissions then a very large number of sites would have to be developed. This in itself would have an impact upon the environment, even if it was mainly a visual one.

Fig 1.
Annual hydrograph of a typical small river. This gives the daily flow over a typical year

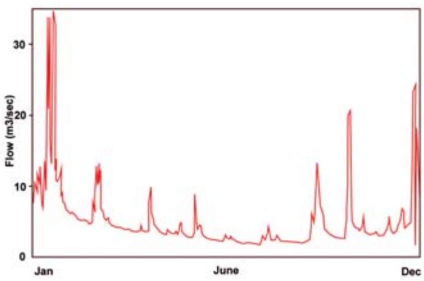
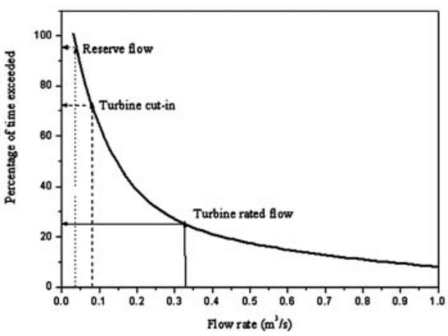


Fig 2.
Flow Duration Curve



Estimating the Potential of a Site

Small water turbines are available with ratings of between 200W and 50 kW. The main factors affecting the amount of electricity generated are the head and the flow rate. The Environment Agency has data on flow from 1,300 gauging stations in major rivers. If no data is available, estimates can be made from long-term rainfall records and knowledge of similar catchment areas. If the project looks feasible, on-site measurements can then be made to estimate the quantity of water that can be abstracted. To be practicable, head of at least two metres is usually needed.

Figure 1 shows the annual hydrograph of a typical small river. This gives the daily flow over a typical year and the flow is seen to be highly variable. From this data the flow duration curve (**Figure 2**) is derived showing how the flow is distributed over time. The reserve flow (typically that occurring 95% of the time) is the water needed to ensure the river never dries up. Maximum power will be produced at the rated flow of the turbine. Below the cut-in flow the turbine will not generate.

Figure 2 shows the turbine will run at rated power for around 25% of the time and fail to generate for around 30%, or 17 weeks of the year. Rivers with flatter flow curves will give greater values and provide a more guaranteed source of power which can be important for remote locations wholly dependent on a single turbine.

The first step to examine the potential of a site is to commission an initial investigation, which will cost about £300 to £1,000. This will consider issues such as turbine site, consistency of flow and volume of water, usable head, the likely acceptability of diverting water to a turbine, site access for construction equipment, grid connection, social and environmental impact on the local area, land ownership, and will provide an initial indication of design power, costs and annual energy output.
If the site proves suitable, a detailed feasibility is required, costing a further £5,000 to £10,000 although for a scheme less than 30 kW the initial investigation may prove sufficient.

Issues

Common issues are:

- **Visual Impact**. The scheme may need various concrete constructions such as the dam and fish ladder. The penstock and the plant house might also be visible. However, hydropower plants are sited in valleys, which greatly reduce their visual impact.
- **Ecological Impact**. Direct loss of habitat due to a small scale hydro plant is minimal. Some short lived disruption will occur during construction. If the water source contains migratory fish such as salmon and trout then a fine mesh screen must be fitted to stop them entering the turbine and a fish ladder must be fitted to by-pass the plant.
- **Noise**. The only source of noise will be the turbine/generating plant. During the design of the system, it is important to determine the level of noise at any nearby properties.

Photo 2.
Small scale micro hydro turbine.

Sizing Tools

A very simple but approximate sizing tool for schools is available for free download from The Centre for Energy and the Environment (www.ex.ac.uk/cee/re). For homes and other buildings a more complicated but more accurate free sizing tool is available from RETSCREEN www.retscreen.net/ang/t_software.php.

Maintenance

Small turbines should be inspected once a year, annual service costs should be no more than 1-2% of the capital cost of the scheme. Most run of river schemes will have a 'trash rack' that prevents debris from being carried down the penstock to the turbine - this rack will need to be inspected and cleaned on a regular basis unless some form of automated cleaning system is included. After 10 to 15 years the generator may need replacing but the turbine is likely to have a life of well over 25 years.

Planning Permission |

Both planning permission for the turbine house and licences from the Environment Agency will be required even for a domestic generator.
An essential part of getting the permission for a proposal is an assessment of the potential environmental impact it might cause. The developer is legally obliged to hire a consultant to assess these impacts in the form of an environmental impact assessment and reports may be required for the Environment Agency and the local planning authority. Both organisations should be contacted early on in the project to ascertain their exact requirements. The Environment Agency will assess whether the scheme needs land drainage consent and an abstraction licence.

Finance |

Costs and Grants
In general, the cost of the scheme per kW of generation will be less the higher the head. This is because higher heads mean less water is needed to produce the same amount of electricity and consequently components are smaller and there is no need for a gearbox between the turbine and the generator. Prices vary greatly depending on the site and approach used. The British Hydropower Association suggests a cost of between £85,000 and £280,000 for a 100kW installation, but suppliers should be contacted for accurate costs.

Various grant schemes are available for home owners, farmers and other businesses. The Low Carbon Buildings programme from the DTI can offer a maximum of £1,000 per kW installed, up to a maximum of £5,000 subject to an overall 30% limit of the installed cost (exclusive of VAT) for home owners

For more details see Grants factsheet.

Large schemes may pay business rates (£9 per kW installed x 0.46, in 2004) and metering costs around £350-£1,000 per annum.

More Information |

- Regen SW has a list of contractors on its website - www.regensw.co.uk/directory
- Energy Saving Trust (www.est.co.uk/myhome/publications/) Renewable energy sources for homes in rural environments (CE70) Energy Saving Trust (www.est.co.uk/myhome/publications/)
- For information on connecting to and exporting to the grid see: www.quietrevolution.co.uk/downloads.htm
- An excellent guide to small-scale hydropower is published by the British Hydropower association: www.british-hydro.org/infopage.asp?infoid=150
- The Environment Agency publishes "Hydropower-A handbook for Agency Staff", which lays out its approach to assessing new schemes (Available from: www.environmentagency.gov.uk/commondata/103599/hydropower_manual_e_882335.doc)