SMALL-SCALE HYDROELECTRICITY

Introduction: Hydropower is a mature and proven technology; it is perhaps the oldest method of harnessing renewable energy. The first water wheels were used for irrigation over 2,000 years ago. Later, they were applied to milling and by the Industrial Revolution their use was extensive. Towards the middle of the 19th century the first water turbines were developed. They were smaller, more compact, more efficient, and ran at a higher speed than the wheel... and were particularly suitable for electricity generation.

Technology: Hydro-electricity converts potential energy stored in water held at height to kinetic energy (or the energy used in movement), turning a turbine to produce electricity. Improvements in small turbine and generator technology mean that 'micro' (under 100kW) hydro schemes are an attractive means of producing electricity. Useful power may be produced from even a small stream. The likely range is from a few hundred watts (possibly for use with batteries) for domestic schemes, to a minimum 25kW for commercial schemes.

Applications: Hydropower requires the source to be relatively close to the site of power usage, or to a suitable grid connection. Hydro systems can be connected to the main electricity grid, or as a part of a stand-alone (off-grid) power system. In a grid-connected system, any electricity generated in excess of consumption on site can be 'sold' to electricity companies. In an off-grid hydro system, electricity can be supplied directly to the loads, or via a battery bank and inverter set up. For off-grid systems, allowances should be made for any seasonal variations in water flow, which can affect the amount of electricity delivered by the system. It is also possible for single households with a mains connection located near a hydro source to install a micro-hydro system. They can go 'off the grid' entirely, or stay connected and sell excess electricity to the grid. The capital cost is high, but the prospect of zero or even negative electricity bills may tempt you! Provided the resource is there, community hydro projects can be a viable proposition. Potentially, there are great benefits in clubbing together to increase buying power or sharing expertise - although the work involved should not be underestimated.

System sizing: One problem with Hydro schemes is that every one is different. Not only do hydro machines change in size with site needs but they can also change entirely in design - usually decided by the "Head" or pressure of water available.

Energy available in a body of water depends on the amount of water flowing per second, and the height (or head) that the water falls. The scheme's actual output will depend on how efficiently it converts the power of the water into electrical power (maximum efficiencies of over 90% are possible, but for small systems 50% is more realistic). Hydroelectric systems are generally divided into 2 categories, low and high head. The former could include old mill sites with a weir and sluice, whilst the latter includes fast flowing upland streams. This equation gives the power contained in water:

P = **H** x **Q** x **g** x **e** where:

P is power measured in kW
H is head measured in metres
Q is flow rate measured in cubic metres
g is gravitational constant (~9.8m/S2)
e is efficiency factor (usually ~0.5, i.e. 50%)

A small turbine on a hill stream with a flow of say, 15 litres/second, and a head of 15m will therefore generate about 1kW, enough to meet the basic needs of a house. It should be stressed that resource assessment is a specialized subject, best left to micro-hydro consultants (who can do a site survey and feasibility study). It is critical that you obtain high quality advice from the outset. Reliable and efficient equipment - and sound advice - is available from a large number of experienced UK suppliers and consultants.

Components of a typical hydro system:

- An intake - often incorporated into a weir, to divert the flow from the watercourse.

A penstock pipe - to convey the water from the intake to the turbine - must be of sufficient diameter to minimize 'head-loss'.
A powerhouse - in which the turbine and generator-set convert the power of the water into electricity.
An outflow through which the water is released back to the river or stream.
Underground cables, or overhead lines to transmit electricity to its point of use - must be of a sufficient size to minimise 'voltage-drop'.

Will it meet my energy needs?: This will depend on the resource available and your energy needs. Houses with no mains connection, but with access to a micro-hydro

site, a good hydro system can generate a steady, more reliable electricity supply than other renewable technologies at a lower cost. Total system costs can still be high, but often less than the cost of a grid connection, and with no electricity bills to follow. Note that in off-grid applications the power is mainly used for lighting and electrical appliances - space and water heating are usually only an option when available power exceeds demand.

Costs: Hydro costs are very site specific.

For low head systems (not including the civil works - so assuming there was 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. These schemes are generally more expensive as they require bigger turbines and more civil works.
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 domestic scheme might cost £20-£25,000. Unit costs drop for larger schemes.

Environmental impacts: Turbines can have visual impact and produce some noise, but these can be mitigated relatively easily. The main issue is to maintain the river's ecology by restricting the proportion of the total flow diverted through the turbine. This will be set as part of the Abstraction License that you need to obtain from the Environment Agency (in Scotland the Scottish Environment Protection Agency). This should be your first port of call for any planning issues.

Legal Aspects: In the UK, the legal requirements for water use and power generation have changed in recent years and it is completely legal to generate your own electricity. Charges cannot be made for the use of the water and connections can be made to the grid for the export of surplus power. There are, however, a number of new legal requirements for the use of water and the construction of any new civil engineering works. All mill rights were taken away by an 'Act of Parliament' a few years ago and unless you registered your rights you may now have to apply for an 'Abstraction Licence' from the Environment Agency. This licence will be for a term of 15 - 20 years and will define the quantity and time when you may take water from the river. It should be noted that you can be charged for water used for ornamental and amenity purposes but not for power generation.

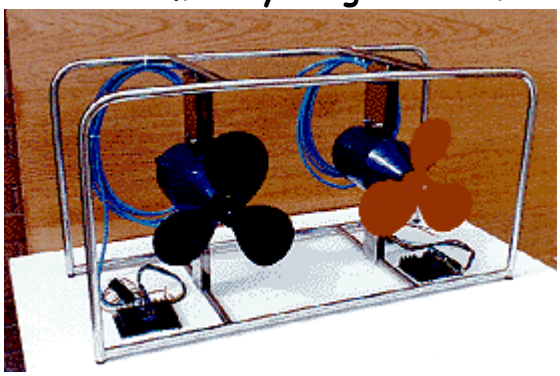
Some samples of small hydroelectric turbines

STREAM ENGINE: The Stream Engine is designed for use in battery-based power systems, with electricity generated at a steady rate, and stored in batteries for use at higher rates than is generated. During times of low demand, power is stored. An inverter is used when AC power is desired.

Water from a stream is channelled into a pipeline to gain enough head (the vertical distance the water falls) to power the system in place. The Stream Engine operates at heads of about two meters (6 feet) and upward. The water passes through a nozzle, where it accelerates, strikes the bronze turbo wheel, and turns the generator shaft. Up to four universal nozzles can be installed on one machine.

The LH1000 uses the same generator as the Stream Engine, however the water turbine component uses a low-head propeller design. This enables the machine to produce power from heads of 0.5 meters (2 feet) up to three meters (10 feet). At the maximum head, the output is one kilowatt.

'AMPAIR' mini-hydro generator. These 100w small direct stream-flow turbines can be placed in any flowing water (including tidal). They start charging at flows below 1m/sec and generate up to 8amps @ 12v.
Proven to depth of 10m. All water joints (mechanical & electrical) are double sealed. The oil filled housing has a pressure expansion chamber to allow operation at intermediary depths & in all temperatures.



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Small horizontal 'Pelton' turbines:

Water flowing along the large diameter pipe is passed through the turbine to generate electricity. Many different sizes and outputs are available.

FUNDING - Low Carbon Buildings Programme grant:

- For domestic premises a government grant is available 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), towards the cost of a hydroelectric installation. See Information sheet 2 – Grants for Renewable Energy Systems.

- Community schemes can apply: Non-profit community organisations such as registered charities, community groups, local authorities and schools.

- Businesses can apply: Stream 2 grants, designed for medium and large scale microgeneration projects, will be launched later this year. This will be open to public, not for profit and commercial organisations.

Contact: http://www.lowcarbonbuildings.co.uk/ or call 0800 915 0990 or contact Cornwall Energy Efficiency Advice Centre on 0800 512012.

Further info on renewable energy, case studies, etc: www.est.org.uk/renewables

British Hydro Power Association; UK hydro industry's trade association wide range of information on applications, case studies: www.british-hydro.org