Thomas Lewton

Water power
The micro-hydro revolution

The River Ribble at Settle in the Yorkshire Dales. The energy of this water is soon to be tapped.

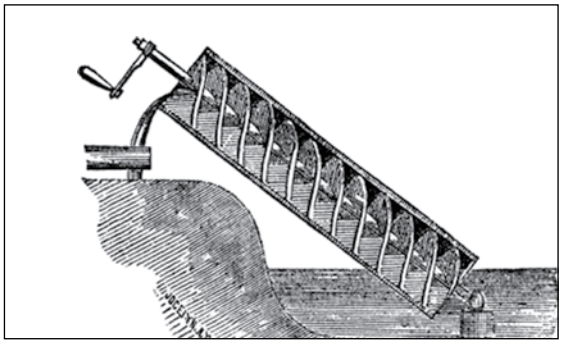
Think hydroelectric, think big. Right? As oil prices soar and global warming threatens, the need for affordable green solutions to the energy crisis is ever increasing. Giant hydroelectric power stations, such as the Three Gorges Dam in China, will help to fulfil this necessity. However, with the benefits of large scale hydro power not so clear cut people are turning back to basics; we are witnessing a new revolution in micro-hydro.

In this article, Thomas Lewton describes one small scale project.

Key words
hydroelectricity
potential energy
electrical power
generator

How does it work?

Micro-hydro is no new phenomenon. Since our agricultural beginnings man has both manipulated and harnessed the energy of our natural water resources. In fact, it is an age old invention, the Archimedean screw, which is currently being put to use around the UK as means of hydroelectric generation.

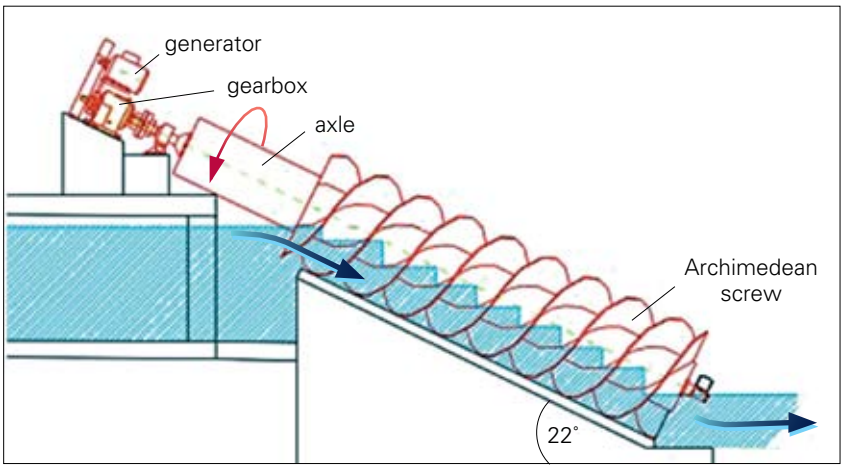


How the Archimedean screw was first used – raising water to a higher level.

The Archimedean screw was invented over 2000 years ago as a means of transferring water uphill from a low-lying body of water and into fields for irrigation. By using the screw in reverse so that water is allowed to flow down it, the weight of the water will turn the screw.

There is an energy difference between two different levels of flowing water, for example at a weir or waterfall. The Archimedean screw harnesses this potential energy and converts it into the mechanical energy of the turning screw which is then further converted into electrical energy using an electric generator.

Micro-hydro is defined to have a generating capacity of less than 0.1 MW. This is roughly enough to power 100 homes and is tiny compared to the Three Gorges Dam's whopping 22 500 MW generating capacity. (1 MW =1 000 000 W)



The Archimedean screw working in reverse, to generate electricity.

Electrical energy is measured in kilowatt-hours (kWh) where 1 kWh = 3 600 000 J and is the energy supplied by 1 kW working for 1 hour.

Micro-hydro in action

The rural town of Settle in the Yorkshire Dales National Park is the latest community to utilize this innovative technology. An Archimedean screw will be installed at the Bridge End Weir on the River Ribble, close to an original mill waterwheel.

Water will be diverted above the weir down an adjacent steel trough holding the screw at an angle of 22°. As the water descends it will turn the screw on average 28 times a minute.

The mill race, the site chosen for Settle's micro-hydro scheme.

The potential energy available at the site depends on two crucial factors: the vertical fall of the water, known as the head height, and the volume of water passing per second, known as the flow rate. The power available from the system is proportional to the product of head height and flow rate.

- The Ribble has a flow of 2650 litres per second.
- 1 litre of water has a mass of 1kg.
- The Bridge End Weir has a head height of 2.3 m.

Potential energy

= mass x gravitational acceleration × head height

= mgh = 2860 kg × 9.8 m/s^2 × 2.3 m = 64.5 kJ

Each second there is the potential to harness 64.5 kJ of energy from the weir. Power is the energy converted per second, so the potential power rating of the Archimedean screw is 64.5 kW. However, energy is wasted, for example as heat, when converting the potential energy to electrical energy.

The Archimedean screw has a conversion efficiency of 77% and so the maximum power rating of the screw to be installed in Settle is actually:

64.5 kW × 0.77 = 49.7 kW.

The flow of a river varies throughout the year so that the average power rating is less than the 49.7 kW. Even so the screw will still generate 184 000 kWh (units) of electricity every year which is enough for 50 average houses.

A micro-hydro system fully installed. This one is at Ashburton in Devon. The generator is in the wooden hut at the top.

How does it all add up?

The cost of the project at Settle is £300 000. Though minute in comparison to the £15 billion Three Gorges Dam, it is still a significant investment for a small community. The benefit of a hydroelectric project, however, is that it can repay its implementation costs comparatively quickly, making it economically viable. Often loans can be taken out for schemes such as the one at Settle and paid back within a few years of operation.

The Settle hydro project is also implementing a community share initiative. Local investors make a social investment by buying shares in the project, providing the funds so that the project can be realised. Eventual profits from the project will be put into regenerating the local economy and promoting the environmental sustainability of the area.

What's wrong with large scale hydro?

Most large scale hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. However, damming can cause major problems for the surrounding ecosystem. The river is obstructed for aqautic life and the downstream river environment is affected by warmer water with a reduced oxygen content. The harms are not only ecological: population relocation as a direct result of dam construction has affected millions of people worldwide.

Obviously it's not all bad! Hydroelectric power eliminates the need for and hence the cost of fuel providing a more economical alternative to fuel powered plants. Large scale hydroelectric plants are undoubtedly needed as an affordable means of meeting power demands in today's world of

This hydro dam at Pitlochry in the Scottish highlands gives an idea of the scale of traditional hydro schemes.

rising prices and instability in fossil fuel resources. Furthermore, as hydroelectric dams do not burn fossil fuels they do not directly produce carbon dioxide (a greenhouse gas). However, the green credentials of some large scale hydroelectric power stations are beginning to be questioned.

A large reservoir is formed behind the dam wall of a hydroelectric power station. The flooded plant material decays in an anaerobic environment producing methane, a potent greenhouse gas. Though this is an insignificant problem in colder climates, in some tropical environments gas emission from the reservoir is actually higher than the emissions of a fossil fuelled power plant.

The benefits of micro-hydro

Micro-hydro avoids many of the disadvantages of large-scale hydro. The Archimedean screw system requires little alteration to the surrounding environment. A slow moving screw and large passages avoid silting up and allow the free and safe movement of fish through the system. There is no possibility of decaying plants releasing methane into the atmosphere as with large hydro projects. In fact this carbon-free technology will save 80 tonnes of carbon a year from the Settle project alone. What's more, as micro-hydro can be connected directly to the local electricity supply, there is no need for electricity to be sent miles along power cables, a huge source of power loss.

If a river has sufficient flow of water, two Archimedean screws can be installed side-by-side.

A fish swims safely past the rotating Archimedean screw.

Though more environmentally friendly than large-scale hydro, micro-hydro produces a great deal less power. All that is required for a micro-hydro system to be installed is a dependable flow of water with a reasonable height of fall and so it is hoped that by introducing a large number of small projects micro-hydro can make a significant contribution to our energy needs.

China is leading the way in investment in small-hydro projects with over 50% of the world's small-hydro resources. Closer to home, the Scottish government has emphasised the need for small-hydro in meeting its green energy targets and a recent report has shown 650 MW could be produced from hundreds of small projects around Scotland.

In the developing world small-hydro can provide cheap and reliable electricity for lighting, water pumping and small industries. The comparatively easy construction and the simple, small nature of the equipment make DIY micro-hydro projects a possible solution in remote rural and mountainous areas where electrical resources are invaluable to agriculture, powering irrigation and crop processing.

As fossil fuels become scarcer and more expensive, investment in alternative energy sources is a necessity. Though micro-hydro may seem insignificant compared to its vastly larger counterparts, by introducing a large number of these grassroots projects micro-hydro may be one of the most environmentally friendly and economical solutions to the energy crisis. With pioneering projects, such as the Settle Archimedean screw, leading the way, local communities can make a real impact on the pressing issues of today.

Look here!

Find out some more ways in which Settle is going green: *www.greensettle.org.uk*

Settle's micro-hydro system is built by Mann Power: *www.mannpower-hydro.co.uk;* look for their movies of micro-hydro systems in action.

The British Hydropower Association has a guide to the science and technology of mini-hydro: *www.british-hydro.org*

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