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FOCUS: ENERGY & ENVIRONMENT

Micro Hydro – the saviour of for a country of waterways?

Executive summary

Micro Hydro is a form of hydroelectric power generation that produces up to 100kW of electricity using the flow of water. Micro-hydro generators are often used to power individual houses or small communities.

In the United Kingdom micro hydro projects are likely to remain beyond most households, unless they are lucky enough to own land which has a small stream with a large head on it, or the property is an old water mill which already has a lot of the hard work completed. But even these fairly simple low flow – high head systems require a large amount of capital initially and the pay-off period may be too long for a lot of people.

For now the future of micro hydro in the United Kingdom seems to be community projects such as Osney Lock in Oxfordshire, where funds are raised for the project through private investors who then receive interest on the amount invested.

In the developing world micro hydro projects can be life changing for the people who receive the power they generate. It allows them access to modern technology, helps them get more productive hours out of the day and can power machinery to make work more effective and efficient. However, it must be demonstrated to the local communities how the project will benefit them and improve their standard of living. If a community does not see how the project will be able to benefit them it is very likely that they will show little interest in the project or in ensuring its long term viability. Local people must also be taught how to maintain and run the plant so that it does not fall into disrepair. The alternative to this is that such projects are publicly funded, which goes against the current trend and imposes a further burden on an already overstretched public purse.

In order to make a significant breakthrough in micro hydro generation at individual property level, technological innovation is required: The generation unit needs to be able to operate with low flow rates (such as those of a normal river flow) removing the need for Mill Ponds or other methods to increase flow rates, Further, the equipment needs to be affordable or at least offer a return on investment over a five year period to be attractive to property owners. If these conditions can be met, the UK might be able to look forward to a significant contribution to energy self-sufficiency from riverside homes,

What is Micro Hydro?

Micro-hydro is a form of hydroelectric power generation that produces up to 100kW of electricity using the flow of water. Micro-hydro generators are often used to power individual houses or small communities. In general their design involves channelling water downhill through a pipeline, and using the water pressure from this to turn a turbine.

The amount of electricity that can be generated at a site depends on the flow rate of the water source, and the amount of vertical drop available (also called the ‘head’). Multiplying the head (feet) and the flow rate (gallons per minute) then dividing the total by twelve will give a good estimate on the amount of watts that can be generated.

The basic components of a small hydro-electric system, running from “water to wire” are:

- Diversion and intake screen—Directs water from the stream or river into the pipe or channel
- Penstock (pipeline)—Carries the water to the turbine
- Turbine—Generates electricity (includes nozzles, runner, and generator)
- Electronics and batteries (if used)—Regulates turbine and stores energy
- Dump load—Absorbs surplus energy
- Transmission and distribution—Delivers the energy to its end use

The cost to install a micro-hydro system varies greatly, depending on the specifics of the location. It costs approximately £1,200 to £4,000 per installed kW. Maintenance costs are fairly cheap, and the amount of money that a consumer can save by installing a micro-hydro system depends on the amount of time during the year that the installation can produce electricity.

The best geographical areas for exploiting small-scale hydro power are those where there are steep rivers flowing all year round, for example, the hilly or mountainous areas of countries with high year-round rainfall. Islands with moist marine climates, such as the Caribbean Islands, the Philippines and Indonesia are also suitable. Low-head turbines have been developed for small-scale exploitation of rivers where there is a small head but sufficient flow to provide adequate power.

A site on a steep hill with fast flowing water is ideal for small hydro projects as they have a high head (or maximum vertical drop) of water. Less than 10m is normally classed as low head, from 10-50m medium, and more than 50m, high. Sites with a very low head such as old watermills are not necessarily suitable hydro sites. A large, slow-moving body of water gives a high torque (turning force), which waterwheels can harness to operate machinery directly, but the low rotational speed makes it difficult to use them for electricity generation. In the United Kingdom it is estimated that up to 15% of watermill sites may be suitable for upgrading to produce hydroelectricity.

High head projects create a greater water pressure, giving a higher flow rate and a faster rotating turbine, which, in turn, means lower torque. The cost of the drivetrain of the generators is closely related to how much torque it has to transmit, so high head projects often cost less because of this. The environmental impact is usually lower with high head too since the pipeline is buried, coming out at a shed or small barn at the bottom housing the generating equipment. Whereas low head projects usually require very large Archimedes screws or Kaplan turbines and need a large civil engineering project to install them.

Micro hydro energy generation, like any form of energy generation, has a number of advantages and disadvantages. The key advantages are the reliability of the energy source (energy generation is continuous and easily predictable), as no reservoir is required the environmental impact is minimal, maintenance fees are fairly small - which makes micro hydro a cost effective solution compared to some other renewable energy sources.

The main disadvantages are that it can be difficult to find a suitable site to locate the facility, it is also unlikely that it will be possible to enlarge the site to increase power generation capacity as the size of the stream will be a limiting factor, in some areas there also may be decreased power generation during the dry summer months if the lack of rainfall impacts on the flow rate of the watercourse.

Source: Alternative Energy News, Microhydropower.net, Homepower.com

Micro hydro in the United Kingdom

In order to operate a micro hydro facility in the United Kingdom a license for water abstraction from The Environment Agency, which can take up to three months and will require an impact assessment on river ecology and to potential flooding. Planning permission may also be needed for the powerhouse building and pipework carrying the water.

Once all the legal paperwork has been satisfied and the project has been completed the owner will be eligible for feed-in tariff payments if the facility is connected to the national grid. These rates change every couple of years (always in a downward direction), the current rates are:

- Hydro generating station with total installed capacity of 15kW or less – 17.17p/kWh (down from 19.31p/kWh before 31st March 2015)
- Hydro generating station with total installed capacity greater than 15kW but not exceeding 100kW – 16.03p/kWh (down from 18.03p/kWh before 31st March 2015)

The total amount of electricity generation capacity in the United Kingdom from hydro power (reservoir and run-of-river schemes) is nearly 1.5GW.2 This is just under 1.5% of the UK electrical power requirement, and it is estimated that there is potential capacity to increase this to 2.5%. There are currently 170 hydro projects receiving feed-in tariff payments in the United Kingdom, and 167 of these are micro hydro projects.

One of the companies pioneering hydro generation in the United Kingdom, Ellergreen Hydro, believes that within the current regulatory framework 1GW of generating capacity could be built using small hydro projects. Currently there are 182 hydro facilities in the UK generating less than 100kW of electricity, nearly half of these generate less than 25kW. Some examples of micro hydro projects in the UK are detailed below.

Source: TheEngineer.co.uk, Ofgem

Osney Lock, Oxfordshire

One of the most recent micro hydro projects in the United Kingdom has been at Osney Lock in Oxfordshire, which only started operating at the end of January 2015. This project is an example of a low head hydropower system, and it uses an Archimedean screw which produces 49kW, and should generate 159,000 kWh every year, enough to power 50 homes. The entire project from planning to opening took 12 years to complete at a total cost of £624,000.

Most of the electricity generated (80%) will be used by Osney Yard which is an Environment Agency site. The EA will pay the same for this electricity as it does currently for electricity from its utilities supplier, which means that the hydro facility will receive a higher price for its electricity than it would by exporting it straight to the grid. The project expects to have paid for itself in 19 years, with a further 21 years of operation which should turn a profit for the operating company. The company also predicts that it should bring £2,000,000 worth of benefits to the local area.

Source: Institute for Sustainability

Mendip Mills, South West England

The purpose of this project was to give 15 historic water mills in Mendips a contemporary purpose. This would primarily be done by installing systems for generating electrical and thermal energy from the water source at each site. 10 of the sites were found to be suitable for generating hydroelectricity, 3 of the sites had potential for more than 30kW, and the other seven had a potential for 5-10kW. The Mendips Power Group received £50,000 of funding in 2004 to pay for the installation of the hydropower systems.

The first mill to be converted was Tellisford Mill in 2007, which had a 55kW generator installed. All the sites combined have an installed capacity of 171kW, an average annual energy output of about 600,000kWh, and an annual saving in carbon dioxide emissions of about 260 tonnes.

Source: Centre for Sustainable Energy

Whalley Community Hydro, North West England

This is a 100kW hydroelectric generating plant which became operational in November 2014. It has been built on the River Calder at Whalley, Lancashire, and is a variable speed Archimedean screw built on a 600 year old weir. The project was started in February 2010, and has cost about £750,000 to complete.

The estimated 345,000 kWh of electricity generated per year is being exported to the national grid and sold to one of the utilities. After the direct running costs of around £23,000 per annum have been accounted for, and taxes, loan repayments, reserves and dividends have been paid the rest of the money earned will be spent on local environmental and other carbon saving projects.

Source: Whalley Community Hydro

Micro hydro in the rest of the world

Hydropower provides a significant amount of the world's energy. Hydropower has been installed in more than 100 countries, and now contributes approximately 15% of the global electricity production. The top 5 largest markets for hydropower in terms of capacity are China, Brazil, the USA, Russia, and Canada, with China far exceeding the others at 249GW. In several countries hydropower accounts for over 50% of all electricity generation, these countries include Iceland, Brazil, Canada, Nepal and Mozambique.

In 2010 the world's top consumers of domestically produced hydroelectricity were:

- China – 163.1 million tonnes of oil-equivalent (mtoe) (6.7%)
- Brazil – 89.6 mtoe (35.3%)

- Canada – 82.9 mtoe (26.2%)
- US – 58.8 mtoe (2.6%)
- Russia – 38.1 mtoe (5.5%)
- Norway – 26.7 mtoe (63.9%)
- India – 25.2 mtoe (4.8%)
- Japan – 19.3 mtoe (3.8%)
- Venezuela – 17.4 mtoe (21.7%)
- Sweden – 15.1 mtoe (29.8%)

Source: Gridovate - Which countries get the most energy from hydropower?

According to The International Energy Agency, if access to electricity is to be truly universal 55% of all new electricity supply will have to come from decentralised systems. Practical Action believe that much of that electricity can come from micro hydropower. The World Bank estimates that 70% of the economically feasible hydro potential in developing countries and 93% of the potential in Africa remains unexploited. Lending for hydro projects by the global financial body exceeded 1 billion US dollars in 2009, most of it going toward the development of small scale or micro hydro projects.

Small turbine technology has been developed in many countries that can allow both shaft power and electricity to be generated from small streams flowing down hillsides cheaply and efficiently. Shaft power can be used directly to drive machinery that can do many of the more laborious tasks that have been traditionally done by hand. For example: rice hulling, grinding grains for flour and pressing seeds for their oil. The use of energy from flowing water allows these tasks to be done much more quickly.

The main use for the electricity that is generated is for electrical lighting. Electric light allows people to extend their day, allowing productive tasks to be done at night. It especially allows students to study for much longer in the day. However, electric lighting can only use 20 to 30% of the available energy that is produced from a micro hydro plant, so other uses need be found for the rest of the electricity.

Over the last 30 years China, Nepal, Vietnam and many South American countries have seen the development of a large number of micro hydro projects that are now providing electricity to many thousands of households. The most micro hydro development has been in Chinese villages where 100,000 very small capacity units have been installed, which amounts to 188.5MW of capacity. Yet although the cumulative capacity of such smaller hydro plants does not show up in the data, these projects are providing essential services to large numbers of populations in a wide range of countries and local topographies and conditions.

Source: European Small Hydropower Association, The New York Times

The Department for International Development has written a paper which details many of the hurdles that micro hydro installations face in developing countries:

"There are several answers to the question why micro-hydro mechanical and electrical programmes have been set up in different countries. A common motive is political; the government wants to be seen as providing development to a remote region, but the cost of grid connection is too high. Micro-hydro electrification is seen as a short cut to providing electricity for these areas, but usually results in a project that is poorly planned and

executed. The political approach can be used by both local and national politicians. Local attempts at influencing people by providing such facilities are usually even more badly designed than national programmes.

Once the system is built, it is usually poorly maintained and often fails very quickly. A better motive is to recognise the constraint that lack of energy places on people's ability to develop and find ways in which micro-hydro power, in various forms, can assist people to overcome this constraint. This approach requires that local people are involved in the decision making process and that the end-uses to which the energy is put do help people to improve their life-styles. Such an approach takes time, as people need to talk through all the implications of how setting up such a project would influence their lives.

If a technology is to be of use to people, they must be willing to own it and use it. Too many technology-based projects have started out as demonstrations, but fail once the demonstration phase is complete, as no-one is willing to take over responsibility for the technology from the agency that has installed it. People need to be motivated to use a new technology; they need to be convinced that it is of use to them and they need to make a financial commitment to use it. For such a technology to be of use to the rural poor, they must be convinced that it will not be drain on their resources, but will help them improve their life-style and offer either a direct cash reward or opportunities to earn such as reward.

The second aspect of a rural energy programme is extension. For a commercial operation, this could be seen as selling a product, but in development terms it is more than that. Extension involves motivating people to use the new technology in a way that will help them improve their life-style, such as by setting up income-earning activities powered by a micro-hydro turbine. For the extension worker, this might involve setting up a co-operative to run the new venture, as well as establishing a market for the products of the venture, if one does not already exist.

Closely connected with extension work is finance. Renewable energy technologies tend to have a much higher capital cost than competing conventional systems, although the running costs are much lower. Rural people must be able to take out a loan to pay the capital cost, but they can usually recover the money to pay back the loan and interest from the money they save running the system. The supply of conventional energy, such as diesel and kerosene, is often subsidised by government, so renewable energy technologies may also need to be subsidised so they can compete. There is often a strong environmental argument for having such subsidies, but this needs to be carefully thought through by government planners and any aid organisation involved in the programme.

If there is financial support for the use of the technology, through loans and subsidies, the job of the extension agent will include helping the individual or group of people involved in the project fill in the appropriate forms to obtain the correct finance. Often rural people find government and bank bureaucracy very intimidating and are not willing to make the approaches by themselves.

Once a person or community has been persuaded to use the technology, the next step is to install it. The installation of micro-hydro turbines demands appropriate skills in site surveying and designing the civil works correctly to match the system. A good system also depends on knowing the energy available from the chosen stream over a full year's cycle. Often the *water flow is only measured at the time the survey is done and people are expected to remember how the flow rate varies over the rest of the year. Any alternative uses of the water, such as for irrigation, must also be considered and negotiations made with other users for any water rights that they might have, either officially or through their traditional usage.*

The next component of a project is the training of owners, operators and users of the system. Many technical systems have failed because the operators are not taught the best way to run them. The operators need, especially, to know how to do routine maintenance, such when to change oil or how to adjust systems to compensate for wear. There should be support available to assist the operators in case of problems with which they are unable to cope, such as non-routine break-down of equipment. This could be supported by the extension agent, the manufacturer or the installer, but should be easily accessible by the operator, so the machine can be made operational again very quickly. Follow-up visits by this support group to the operators help to build up this contact, provide the opportunity for further training and allow the support staff to assist with routine maintenance work.

The operation of the equipment is not the only area in which support is required. If the micro-hydro system is being used to generate income such as selling services, good accounts are needed to ensure that customers are correctly charged for these services and that the money is used wisely. If a loan has been taken for the purchase of the equipment, then the bank should be able to check that income is available for making loan-repayments. Owners should therefore be training in simple book-keeping and money management."

Source: Community Micro-Hydro in LDCs: Adoption, Management and Poverty Impact

In summary, just installing a micro hydro plant in a community is not enough if the facility is to be a long term success and a benefit to the community. The local population must see how they can benefit from it, they need to be trained in maintaining the facility, and the facility must be financially sustainable.

Below are some examples of micro hydro projects from around the world:

Japan

In Japan's Tochigi Prefecture, an agricultural cooperative has been generating electricity through hydropower stations which were installed in 2006 and are powered using their rice irrigation water. The two devices generate 30kW and 90kW. This is one of the first examples of using crop irrigation water to generate electricity, and the power generated allows the facility to be self-sufficient. The total cost of the installation was 12 million US dollars, and the Nasunogahara Land-use Improvement Union expects to see a return on that investment in 2016.

Source: Our World (United Nations University)

Peru

In Peru, micro hydro systems have been installed since the mid 1990's and by 2010 there were 57 in total supporting over 30,000 people. Many of the installations were arranged by Practical Action, an international NGO. They designed turbines and used local manufacturers to build them, local communities contributed labour and set up management groups to arrange tariff costs and maintenance which is provided by local technicians.

The generators not only do they provide electricity for light bulbs and other small appliances, they can also supply continuous power for local clinics, allow people to use fridges and run small businesses. Household energy expenditure has actually reduced by more than half, and 60% of families said their incomes have increased. The Peruvian government has a ten-year plan to expand the project, and the technology is now being used in other parts of Latin America.

Source: Practical Action, The Guardian

Argentina

Hydroelectricity currently generates 41% of Argentina's electricity, around 42GWh. Argentina has the potential to produce 1.81% of its total electricity from micro-hydropower, but currently only 0.88% of this is being utilised. Argentina has a national law on the promotion of renewable energy sources for the production of electricity (Law26 190/06). This law grants renewables the status of national interest, and via a tax based incentive a non-binding renewable target of 8% is set to be achieved by 2016.

The Energy Department's Office is currently bound to encourage the construction of 116 micro hydro plants, however, at the moment there are barriers to this development. There are constraints on the government agencies responsible for providing policies which can solve these problems, and because of this the regulatory framework remains insufficient. Foreign investors perceive that there are high risks and a lack of incentive based on the limited availability of local finance. The difficulty in securing capital at reasonable costs in the short term strongly hinders the volume of investment, despite the countries resource potential.

Source: Small Hydro World, The UN, The US Commercial Service

Nepal

Micro hydropower plants are installed in Nepal's remote hilly and mountainous areas. These are mostly used to provide electricity for lighting, computers and other small electrical devices and for food processing such as grinding, hulling, and milling grains and seeds.

Nepal's first micro hydro facility generated 5kW and was installed with the help of the Swiss in 1962. Now there are roughly 2,900 micro hydro plants in Nepal, generating 28MW of electricity and supplying 350,000 households. One of the reasons micro hydro power has been such as success in Nepal is that the country has a large number of micro hydro experts who are capable of carrying out a project from the feasibility study through to the installation and maintenance.

Micro hydro has also benefited from the establishment the Alternative Energy Promotion Centre (AEPC) in 1996 by the government of Nepal. The Rural Energy Development Programme and Renewable Energy for Rural Livelihood have used micro hydro and other renewable energy sources to increase rural living standards in Nepal.

Source: Nepal Micro Hydropower Development Association

Manufacturers of Micro Hydro Systems

TGV Hydro Ltd

TGV Hydro are a Welsh company who specialise in small scale high-head hydro projects, TGV Hydro have installed twelve schemes with a total of 282kW of capacity.

www.tgvhydro.co.uk

Western Renewable Energy

Western Renewable Energy are based in the South West of England, and are the UK's leading independent designer and installer of Archimedean screw turbines. To date they have installed 9 Archimedean screw turbines, with a combined generating capacity of 409kW. They have also installed 8 medium head crossflow systems and 3 high head Pelton systems.

www.westernrenew.co.uk

Spaans Babcock bv

Spaans Babcock have their headquarters in The Netherlands, but also have operations in the UK, Canada, France and Germany. They manufacture and install Archimedean screw turbines and generators up to 500kW in size. They have completed micro hydro installations in Austria, Italy and the UK ranging from 11kW to 90kW.

www.spaansbabcock.com

Renewables First

Renewables First are based in the South West of England, and specialise in the design and installation of micro and small hydro projects as well as wind turbines. They have recently completed a 165kW Kaplan turbine installation at the Earl of Plymouth Estates in Shropshire.

www.renewablesfirst.co.uk

Newmills Engineering Ltd

Newmills Engineering are based in Bristol, UK, and manufacture various types of hydro power turbines, they are the only company in the United Kingdom to produce regulated Axial flow turbines. Some of their projects include a 100kW pelton turbine at Scatwell Lodge and a 75kW axial turbine at Morar Estate, both in Scotland.

www.newmillsengineering.com

Gilbert Gilkes & Gordon Ltd

Gilkes are based in North West England and is one of the UK's leading manufacturers of hydroelectric turbines, and offers compact turbines between 50kW and 100kW. Gilkes installed an 89kW Turgo turbine in Loch Linnhe as part of The Abernethy Trust Hydro Scheme.

www.gilkes.com

Important:
We have used our best endeavour and knowledge to research the answers to questions posed. We cannot guarantee that the information provided is absolute in its accuracy or completeness.

