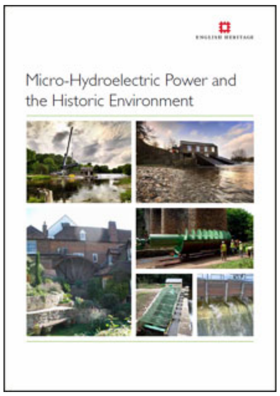
Micro-Hydroelectric Power and the Historic Environment



On 1st April 2015 the Historic Buildings and Monuments Commission for England changed its common name from English Heritage to Historic England. We are now re-branding all our documents.

Although this document refers to English Heritage, it is still the Commission's current advice and guidance and will in due course be re-branded as Historic England.

Please see our website for up to date contact information, and further advice.

We welcome feedback to help improve this document, which will be periodically revised. Please email comments to guidance@HistoricEngland.org.uk

We are the government's expert advisory service for England's historic environment. We give constructive advice to local authorities, owners and the public. We champion historic places helping people to understand, value and care for them, now and for the future.

HistoricEngland.org.uk/advice

ENGLISH HERITAGE

Micro-Hydroelectric Power and the Historic Environment






PLANNING AND HISTORIC BUILDING LEGISLATION

Installing a renewable power generation scheme can be both financially and environmentally rewarding. It is important to ensure that the historic significance of any feature that may be affected by the scheme is fully understood before physical work commences.

In deciding how best to incorporate a low-carbon or renewable technology, the principle of minimum intervention and reversibility should be adopted whenever and wherever possible.

English Heritage is the government's adviser on the historic environment. Central to our role is the advice we give to local planning authorities and government departments on development proposals affecting listed and traditional buildings, conservation sites and areas, terrestrial and underwater archaeological sites, designed landscapes and historical aspects of the landscape as a whole. For our policy statements on climate change and energy, refer to English Heritage's website.

TEXT CONVENTION

Technical terms that appear in **bold** when first mentioned in the text are explained in the Glossary.

COVER IMAGES

top left - © JN Bentley Ltd/Morgan O'Driscoll photography
bottom left - © Stephen Bartlett
top right - © JN Bentley Ltd/Morgan O'Driscoll photography
middle right - © MannPower Consulting Ltd
bottom centre - © MannPower Consulting Ltd
bottom right - © Bilfinger Water Technologies Ltd

Content

Introduction

The energy used to heat, light and run our homes accounts for around 24 per cent of the UK's greenhouse gas emissions – 130.5 million tonnes (2011)[1]. Carbon dioxide is a by-product of the burning of fossil fuels to supply energy, and emissions have spiralled upwards as our demand for energy has increased. Energy-efficiency improvements, such as increased levels of insulation and the use of energy-efficient boilers, can reduce a household's carbon emissions.

Water has been used as a source of power for thousands of years. The earliest watermills in England date to the Romano-British period. The most common design had a wheel on a **horizontal axle**. The number of watermills increased as they became important parts of the medieval economy. The industrial revolution gave rise to new machines for industrial processes that needed ever larger amounts of power to drive them. Increased knowledge, skills and fabrication techniques meant the creation of materials that had previously not been available. Water wheels could be made in larger dimensions to fulfil the growing need for power.

In the mid nineteenth century, with increasing research and development into harnessing electricity, different methods of electrical generation were explored. Electricity generated though the mechanical rotation of a shaft, could be achieved using a waterwheel. A faster spinning shaft could generate electricity more efficiently than one that span more slowly. The slow and powerful rotation of large waterwheels was sometimes **geared up** to a faster shaft rotation, and smaller turbines were made which would spin at a faster rate.

Electricity created from the kinetic and potential energy of water is known as **hydroelectricity**. This is a zero-carbon technology, as no carbon is emitted in the generation of the electricity. The total hydroelectric **installed generating capacity** in the UK in 2011 was around 1676MW (megawatts). This accounted for 1.9% of the total power generation in the UK and 14% of the renewable energy generation. Most of the power is generated in large-scale schemes, which are those producing more than 5MW (enough power for around 1,000 homes). A study funded by the Department for Energy and Climate Change and the Welsh Assembly Government in 2010 determines that there is between 130MW to 185MW of potential capacity for hydroelectric power in England that could be exploited.

This guidance looks at micro-hydroelectricity. These are systems with a power output of less than 50kW. Smaller systems are likely to be around 5kW, which, with other power saving measures and an appropriately sized battery pack, should be suitable for powering an average domestic property.

Hydroelectric generation is often well-suited to sites with historic significance. These sites may contain;

i. buildings such as watermills with existing mill wheels;
ii. buildings which were once mills but have since been converted to other uses, and so only remnants of the original use are visible;
iii. sites with existing infrastructure suitable for a hydroelectric scheme, or;
iv. other sites where potential for hydroelectric generation has been identified.

The sites can be located in isolated areas, where on-site generation can cost less than installing a connection to the National Grid.

[1] 2012 UK Greenhouse Gas Emission, Provisional Figures and 2011 UK Greenhouse Gas emissions, final figures by fuel type and end-user.

21' x 5' Overshot Wheel at Hythe Mill in Kent (Photo courtesy of Stephen Bartlett)

01 What is Hydroelectric Power?

HISTORIC OVERVIEW

Watermills were in use in Britain during the Roman period though their numbers were small (about five sites are known). A resurgence in water engineering seems to have occurred in the mid Anglo-Saxon period, from about the eighth century on. The most famous example is the mill excavated at Tamworth, which had a wheel on a vertical axle.

The Domesday Book, a survey undertaken for the purposes of taxation in 1085-86 that gives a snapshot of England at the end of the Anglo-Saxon period, lists over 6000 mills. 'Mills' here refers to machinery rather than buildings (of which it is estimated there were over 5000), nearly all being water-powered, with a small proportion powered by animals. Windmill technology appeared in the twelfth century. Many of these would have been established milling sites, perhaps in use for centuries prior to the survey, and some were to remain in use right up to the nineteenth century and even the present day. It is not known how many of mills listed utilised waterwheels on a horizontal axle and how many used waterwheels on a vertical axle.

The existence of extensive water supply systems, although not mentioned explicitly, can be inferred from the listing of mills. An implication of the sheer number of mills listed in Domesday is that river systems in England were already heavily engineered and under a high degree of control by the eleventh century.

Wheel before refurbishment at Knockando Wool Mill (Photo courtesy of Hugh Jones)

Throughout the medieval period watermills were an important part of manorial and monastic economies. A typical mill belonged to the Lord of the Manor, with all corn grown on the manor required to be milled there, by payment of a toll. Many mills were turned to other uses such as fulling cloth, sawing wood, crushing stone and sharpening tools or weapons. It has been argued that a medieval version of the industrial revolution took place, having watermills and their associated water supply systems at its heart. Certainly the existence of the material infrastructure of milling (the heavily engineered river and leat systems as well as the mills themselves) laid part of the foundation for the Industrial Revolution of the late eighteenth and nineteenth centuries.

In the nineteenth century steam power was used first of all to increase the flow of water against the wheel, later to drive the wheel directly, providing power for large workshops and factories.

From the late nineteenth century onwards, hydroelectric generation increased in popularity. Technical developments meant turbines became the more common solution, the smaller size made installing systems considerably less expensive per kW of installed generating capacity. Hydroelectric schemes were not only used for factories but also in some domestic situations, such as at Cragside and Castle Drogo, both of which are now owned by the National Trust.

From the mid 1950's, the introduction of the National Grid meant there was less necessity for micro-generation, electricity being available at low cost. There have been a number of factors increasing the interest in micro generation: the increase in the cost of electricity, fear of supply security, increased awareness of sustainability and financial incentives.

A modern overshot wheel installation (Photo courtesy of Potential Energy)

02 How do Hydroelectric Systems work?

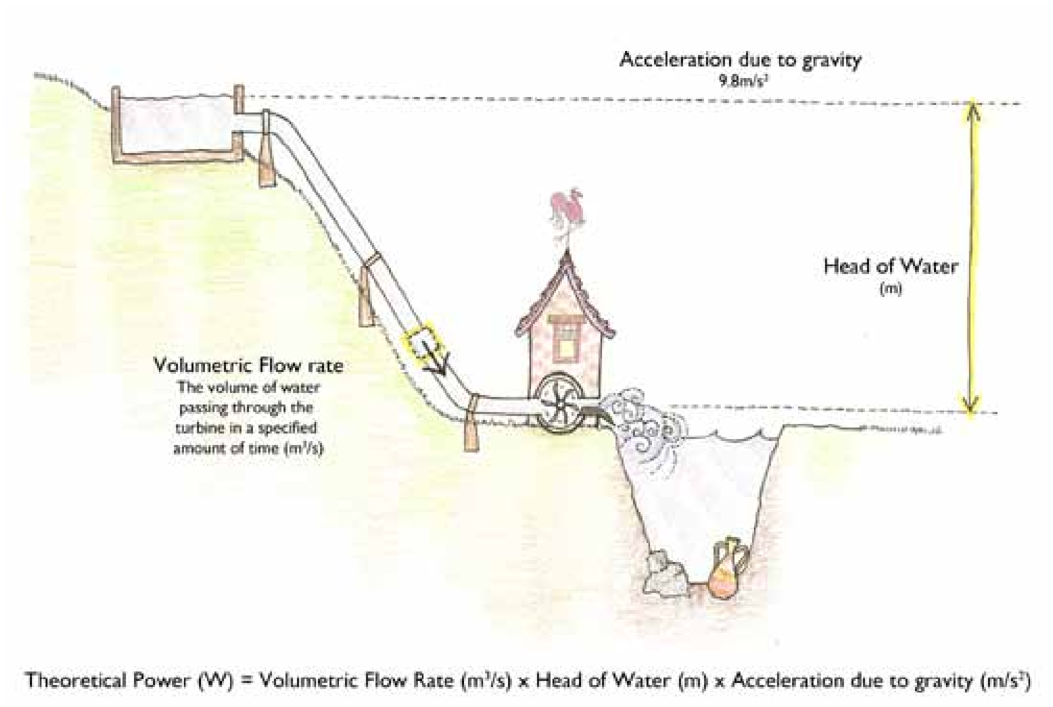
AMOUNT OF POWER

The **theoretical power** that can be generated on a site is dependent upon two main aspects. These are the **volume flow rate** and the **head of water**.

i. The volume flow rate is the volume of water flowing in a set time period, given in units of cubic metres per second (m^3/s). There are a number of different ways volume flow rate can be measured: a minimum of one year's worth of monitoring and recording will be needed to ascertain the average, peak and minimum flow levels. The National River Flow Archive has information for a large number of rivers in the UK.

ii. The head of water is the vertical distance over which the water will influence the wheel or turbine. This will be the distance between the top of the penstock and the turbine, or the height over which the water exerts force on the water wheel.

The **actual power** that can be generated is a percentage of this theoretical power and is dependent upon the particular system that is installed. As an initial estimate, it can be assumed that 50% of the potential energy can be turned into electricity.

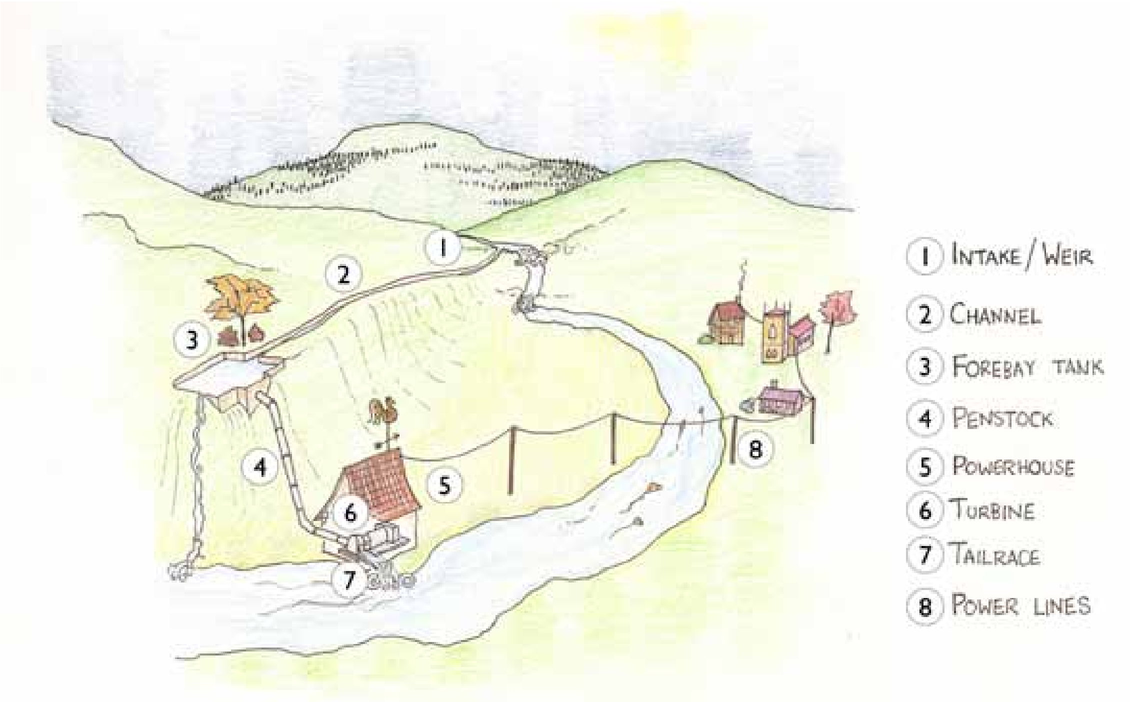


Head and flow calculation – A higher head means a lower flow rate is needed to generate the same amount of power: smaller and less expensive equipment is needed (CT)

The system will be sized depending upon the volume flow rate and head of water. The system will only run when there is enough flow. A minimum flow rate not passing through the hydroelectric scheme will usually be dictated by the Environment Agency. As the flow will have been monitored over a period of time, the amount of power that will be generated can be calculated quite accurately.

SYSTEM OPTIONS

Although there are a many different possible combinations of components in hydroelectric schemes, there are parts common to most.



An example layout and components of a hydroelectric scheme (CT)

INFRASTRUCTURE

Infrastructure is any landscape feature that can be defined, either natural or resulting from human intervention. This will encompass both large scale characteristics, such as the path of the river, and smaller features on a particular site, such as a wheel pit.

The lay of the river system as it exists may be of historic significance. Important existing infrastructure on a wide scale consists of the architecture of the 'stepped' watercourse, characteristic of most English lowland rivers. This river architecture consists of a series of transitions or 'steps' between upper and lower levels, often in the form of weirs (many of which once functioned as mill dams and were part of historic watermill landscapes). Each 'step' represents a point where a hydropower scheme could be installed.

The smaller infrastructure features may also be of significance. For example, a boat slide on the Great Ouse is now a hydroelectric generating site.

A boat slide on the Great Ouse river. Photos show before the scheme was installed, and after with the turbine building and the two 20kW Archimedes screw turbines underneath a protective grille. (Photo courtesy of Matthew Edgeworth)

INTAKE

The topmost intervention in the water course: from where the water is taken or where the river is diverted into the headrace. This separates the installation from the main river flow, making it less susceptible to flood waters and maintaining the head during peak flows. The existence of historic intakes and weirs often makes a project economically viable. This is one of the technically challenging parts of an installation, since where work is undertaken on weirs or intakes, the water will need to be redirected or a dam erected.

FOREBAY TANK

A stilled body of water, where silt, mud and other debris can settle out.

TRASHRACK

A screen or grille to stop debris entering the penstock or turbine. There are many options for these, ranging from those that need regular maintenance, to mechanically self-cleaning systems. Coanda screens are a type of self cleaning screen with no moving parts, which are suitable in certain circumstances.

Forebay tank and trashrack (photo courtesy of Stephen Bartlett)

PENSTOCK

This pipe delivers the water from the river to the turbine. Typically it will be made from a plastic (HDPE or uPVC) or mild steel. A 25kW, high-head, turbine installation is likely to have a penstock of around 280mm in diameter.

WEIR

The weir provides the head of water. This can either feed directly into the wheel, or provide a place to locate the penstock. Maintaining the condition of the weir is very important. If the weir was to wash away, the head of water would be lost. The high cost of building a weir can often be prohibitive.

WHEEL OR TURBINE

Traditionally, the decision between using a wheel or turbine is determined by which option is likely to return the highest efficiency, or highest power output for the given site. However, where hydroelectric turbines or wheels are considered on sites of historic importance, the disturbance to the historic asset, landscape setting, and the reversibility of any installation must be considered as a factor of high importance. The visual effect of any new installation on a site of historic significance is also crucial. Each different wheel or turbine option will incur different civil works, infrastructure requirements and associated components, and these must all be taken into account when making the final decision.

Penstock (blue pipe) leaving a coanda screen
(Photo courtesy of Dulas Ltd)

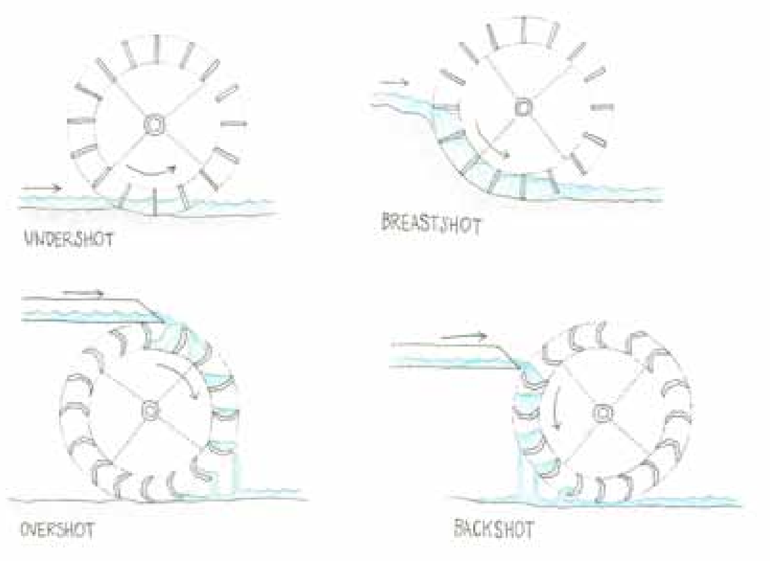
WATERWHEEL

A waterwheel will never be the most efficient way of generating electricity, but there are a few reasons that one might be installed:

i. a waterwheel is currently in place, which is being refurbished and attached to generating equipment,
ii. a waterwheel was previously in the same location, and a new waterwheel is made specifically for that location.
iii. the sensitivity of the site means that a waterwheel is the only permitted option,
iv. the aesthetic qualities of a waterwheel are chosen above the increased efficiencies that would come from a modern turbine.

An undershot wheel only uses the energy in flowing water (as opposed to the potential energy from gravity acting on the water). This means that a significant head of water is not needed. The efficiency of an undershot wheel will be between 25% and 45%.

The breastshot, overshot and backshot wheels are the most commonly occurring water wheels. These are all fairly similar designs, the main difference being in where the water is delivered to the wheel and bucket. The efficiencies of water wheels of these types is usually between 40% and70%.



Different types of horizontal axle waterwheel (CT)

ARCHIMEDES SCREW

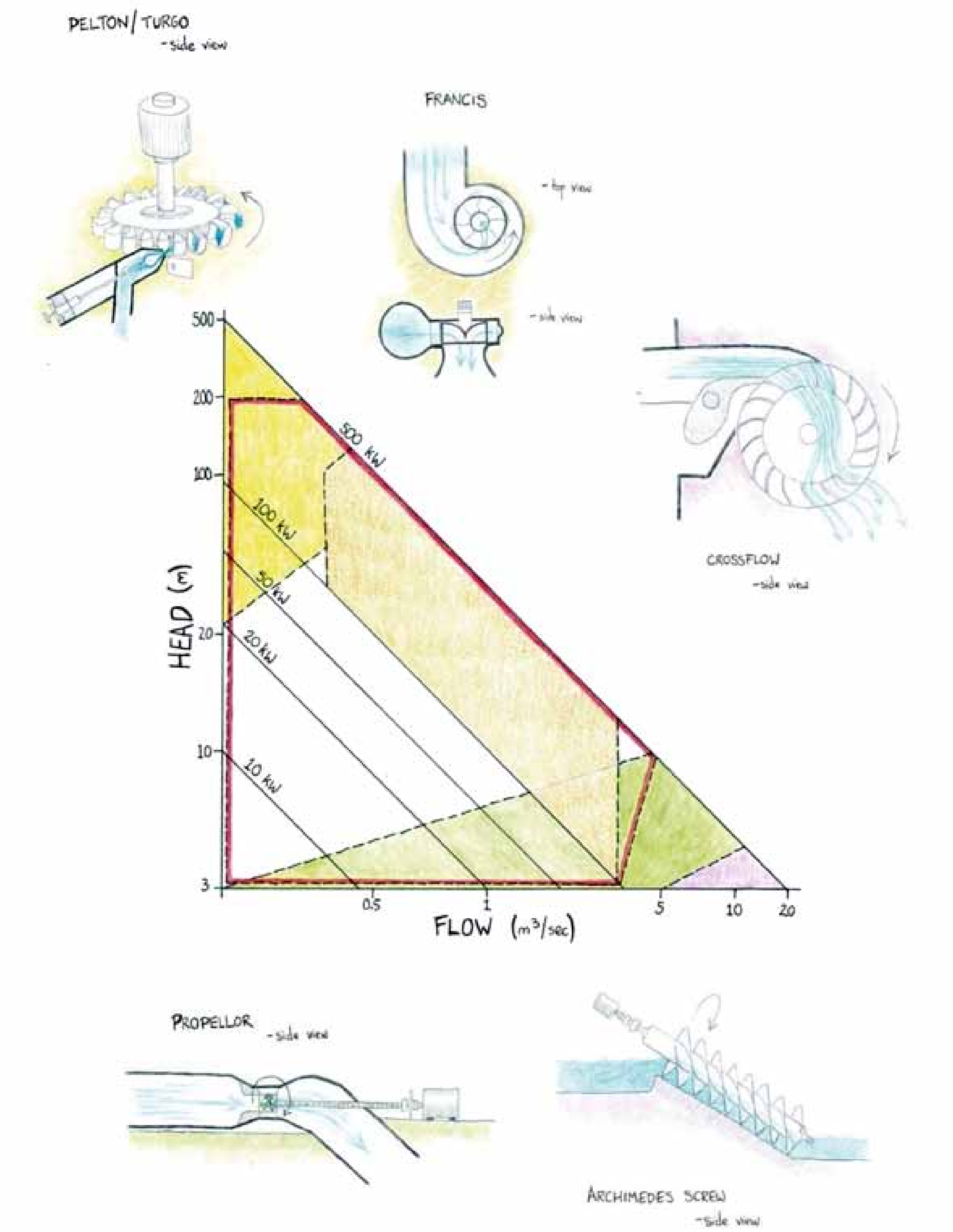
In an Archimedes screw, traditionally used to pump water uphill, the turbine is in the form of a helix. This design is becoming a popular choice for high flow rate, low head schemes due to the high efficiencies attainable. A minimum head on an Archimedes screw turbine is around 1.5 metres.

Archimedes Screw turbine and fishrun at New Mills (Photo courtesy of MannPower Consulting Ltd)

Archimedes screw turbine (Photo courtesy of Stephen Bartlett)

TURBINES

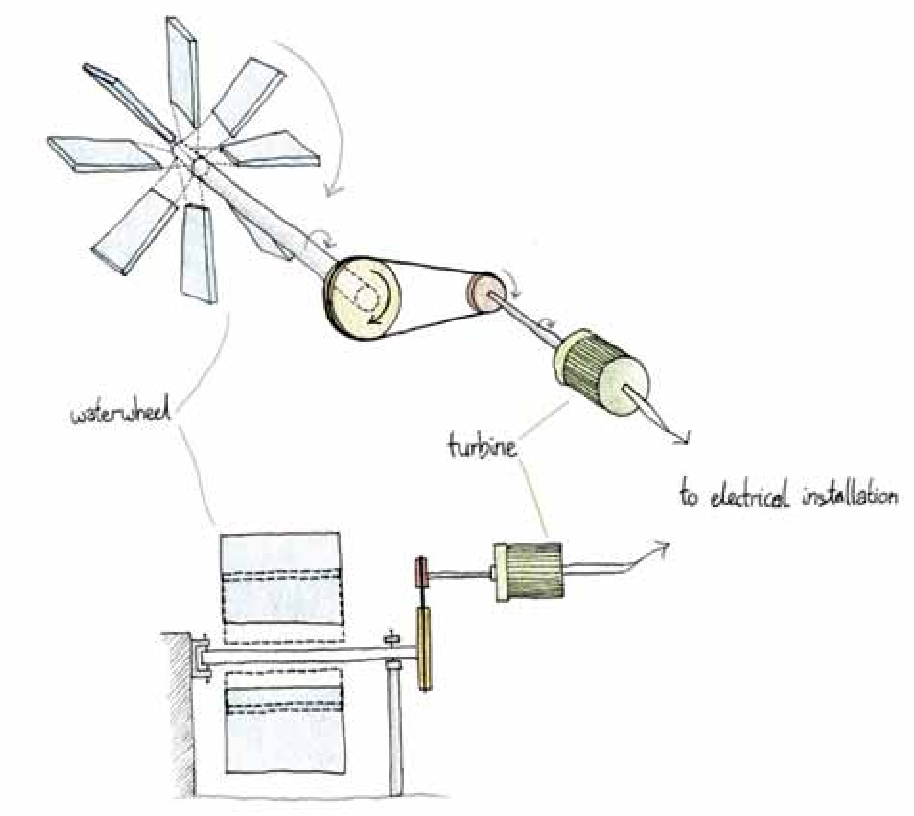
A number of different types of turbines are available, including 'impulse' turbines such as the Pelton or Turgo, and 'reaction' turbines such as the Francis or the Kaplan. All look very similar, and moreover are usually encased, so appearance is not usually important. The choice will instead depend upon the characteristics of the water flow: the head, and the flow rate.



Different types of turbine with graph showing what type of turbine is likely to be best dependent upon head and flow (CT)

POWERHOUSE/ELECTRICAL GENERATION

The mechanical energy of the rotating turbine or wheel is changed into electrical energy via a generator. Generators commonly work most efficiently with a rotational frequency between 1000rpm and 3600rpm (revolutions per minute). A turbine shaft is unlikely to be able to spin at this speed so some method of gearing is usually installed. Generator efficiencies are between 65% and 90%, and either **ac (alternating current)** or **dc (direct current)** generators can be used: for smaller installations, dc is more common. Advice from appropriately qualified professionals should be taken to choose the most suitable generator for the situation.

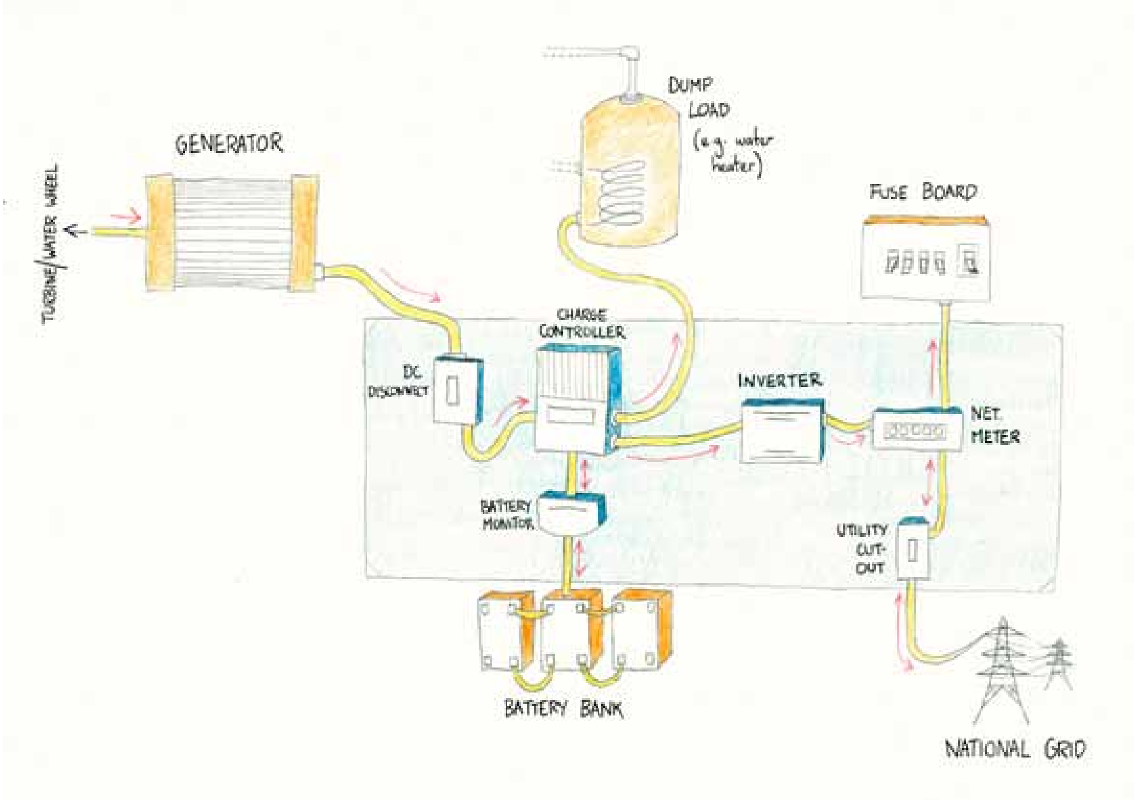


Generator connection (CT)

Generator connection (Photo courtesy of MannPower)

Where there is no connection to the **National Grid**, the site electrical loads can be managed most effectively using a charge controller. This will create a priority order of use, so that when fewer electrical appliances are being used, the generated power can be directed to less time-dependent loads such as water heating. A large battery bank may also be installed to store electricity when there is a smaller demand. Having electricity stored in batteries means more electricity will be available at peak times.

If pre-feasibility and initial works have shown that the installation can be connected to the National Grid, and that therefore excess electricity can be sold, the electricity meter may need to be changed from an incoming-only meter, to a net or two-way meter.



An example of an electrical installation (CT)

TAILRACE

Delivers the water from the turbine or wheel back to the main run of river.

DECIDING WHETHER HYDROELECTRICITY IS AN OPTION

POTENTIAL SITES

Hydroelectricity can be generated on a wide variety of sites. The only necessity is that the site has river or stream that drops by at least 1.5m. These are likely to be sloped sites with a stream or river which flows all year round.

Hydroelectric power generation is often used in remote locations as an alternative to connecting to the National Grid. A new connection to the National Grid can be expensive often exceeding the cost of installing the hydroelectric scheme. No monthly electricity bill will need to be paid with an off-grid hydroelectric scheme.

On a site with an existing water wheel, every effort should be made to maintain it in-situ. The wheel may need restoring, either in part or more extensively. If a new wheel needs to be constructed, using traditional skills and local craftsmen should be explored as an option.

Flatford Mill has recently had an Archimedes screw turbine installed (Photo courtesy of MannPower consulting Ltd)

Where a mill exists and the water wheel has not survived, there may be **infrastructure** in place to make installation of a **turbine** more economically viable in one or more locations. This must be done with care and due consideration for how this may indirectly affect other historic assets. For example, the original wheel pit may still exist. Items of historic significance which may be indirectly affected such as mill machinery must be identified. If the wheel pit is used for the installation of a hydroelectric scheme, the likelihood of a future owner of the mill reinstating the wheel and machinery will be reduced.

The Knockando Woolmill Trust repaired the waterwheel on the site in 2012 (Photos courtesy of Hugh Jones)

Any new hydroelectric system attached to a building must be designed ensuring the significance of the heritage asset is not substantially harmed. The new installation may be one of any number of different types of wheel or turbine. How the new scheme interacts with the existing environment is a key consideration. This includes, but is not limited to;

i. how the wheel or turbine is attached to the ground,
ii. whether the building structure is strong enough to cope with the imposed forces,
iii. any **ground works** that will need to be undertaken,
iv. how the **generator** is attached to the ground or building,
v. any places that a historic building is penetrated,
vi. where cables are laid under or above ground,
vii. where cables are laid within the building,
viii. how any items such as electrical distribution boards are attached to the building.

Linton Falls: A community restoration of a hydroelectric scheme (images courtesy of JN Bentley Ltd/Morgan O'Driscoll photography)

CONSERVATION CONSIDERATIONS

The installation of a renewable technology may require alteration of an asset of historic significance. English Heritage seeks to ensure that any work in the heritage environment sustains or enhances the significance of the asset.

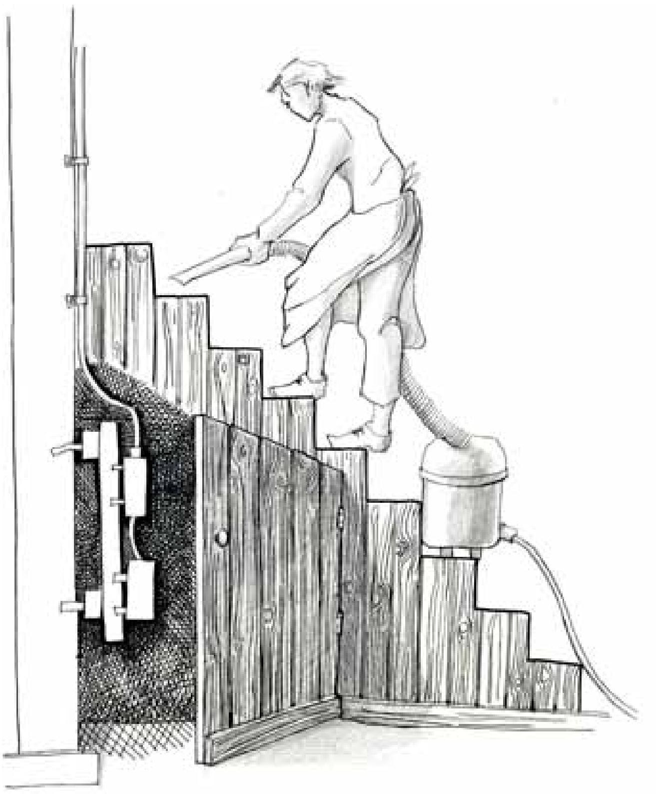
The installation (and later removal) of the hydroelectric system should be considered with great care. It is often a good exercise to think of each component individually to decide how best to approach installing and removing them.

Alterations should be based upon the extent to which they will affect the significance of a historic asset. Any harm to the significance of a building or site should be supported by clear and convincing justification and considered against the public benefits of the work.

The visual impact of the hydro-electric system is vital to the success of the project. Damage to the significance of heritage assets as a result of alteration of the historic setting can be caused by new structures inserted into a building or site, or modern equipment which confuses the story of the site. Further information on this can be found in *The Setting of Heritage Assets*, an English Heritage publication available at www.english-heritage.org.uk/publications.

Hydroelectric systems have many different components, and these are connected together with pipes, chains, belts or cables. Since these latter will need to run between the turbine, generator and electrical system, a path will need to be found through, under, over or around the building's exterior envelope without causing irreparable damage, or making the building less weather tight. Wherever possible existing holes should be used; for example, it may be possible to remove a brick from one of the exterior walls. Permanent damage (for example, cutting holes through joists, floors, walls or ceilings) should be avoided, and it is important to take into account how the hydro-electric system might be removed again if necessary without irreparably damaging the building. If any materials removed are historically important, they should be carefully labelled and safely stored so that they can be returned to position should the hydroelectric system ever be removed in the future.

As well as the building, wheel pit and waterwheel there may be other historic infrastructure that requires careful assessment, such as mill ponds, dams, weirs, headrace, tailrace, hidden archaeological material, etc. The use of **patresses** to mount equipment may be a way to reduce impact on the historic fabric.



Mounting on a pattress (JD)

In any hydroelectric scheme, pipes and cables will either be laid above ground or below ground, each with their own considerations. Underground cable routing can disturb buried archaeological remains: above ground cables can destroy the setting of historic assets. Earth bunding can often provide a solution to these problems. The best option will depend upon the particular scenario. In some situations, the pipe or cable will run both underground and over ground at different points. This solution is also effective if pipes are laid over a site. The pressures encountered can make pipes susceptible to moving: especially at changes of direction and where the pipe meets the turbine. This means an above ground pipe, or one that has been bunded or buried at a shallow depth may need anchoring to the ground.

Earth bunding over a pipe (CT)

03 Planning the Installation

Planning and design should be iterative processes where the suitability of the system is frequently questioned within the specification and project constraints. Any alteration to a building must be carefully considered, and this especially applies to installing hydroelectric power generation. The efficiency of the hydroelectric system can be maximized, and the largest possible savings can be achieved through the implementation of a detailed planning process.

Determining whether a hydroelectric scheme is feasible can be costly and time consuming. To reduce the chances of unnecessary expenditure, there are some initial investigations that can take place with minimal financial outlay.

1 WATER

Establish contact with the Environment Agency; ask them informally whether there is a likelihood of getting an **abstraction licence**. Find out if river flow data is available from the National River Flow Archive for your stretch of river. The turbine size can be approximated once the head and flow rate have been estimated.

2 ELECTRICITY

Is there currently electricity on the site? The electrical distribution company will need to be contacted. This may not be the company to whom bill payments are made, but the company that manages the infrastructure. Contact them to find out whether it would be possible to connect to the grid on the site, and if so whether the connection would need to be:

a) single-phase (limiting the size of the installation),

b) three-phase.

You can also find out if you will be able to sell electricity back to the supply company at this point. There may be financial incentives such as the feed-in-tariff, which can dramatically affect the amount of time the scheme will take to pay for itself.

3 PLANNING

Establish contact with the local planning authority. Ask informally whether a planning application is likely to be considered favourably and whether there are any specific commonly occurring issues in your locality. Consult your local planning authority historic environment service (both historic buildings conservation and archaeological officer) to determine any necessary permissions; they should also be able to give you help and advice about the best type of installation for your type of building and any additional information requirements included a Design and Access Statement.

4 PRE-FEASIBILITY

Engage a company to perform a pre-feasibility study. This will determine;

i. An outline hydrological survey (volumetric flow rate of water, head, etc. to produce a flow duration curve). The water source must be measured for a period of time before the scheme is installed.
ii. How much power might be generated with the water source on your particular site,
iii. Likely revenue from grants and electricity sales,
iv. Likely suitable locations for the installed equipment,
v. A risk assessment of the project including mitigation,
vi. The associated building's electrical load, to determine how much of this could be catered for by the hydro-electric installation.
vii. Other factors that might affect the installation.

Most projects will take between one and three years to complete. At least three months should be allowed for planning and design. Typically, an order for a bespoke turbine will take between 5 and 9 months to fulfill. A four week period should be allowed for commissioning and handover. Depending upon the design, site complexity, location and the size of the turbine, construction time on site can be minimized.

Hele Mill in Devon. A typical West Country mill (Photo courtesy of Stephen Bartlett)

CONSENTS AND LEGISLATION

PLANNING AND HISTORIC ENVIRONMENT LEGISLATION

Work may need permissions of various kinds. The Environment Agency will need to be consulted as their approval is crucial. Installing hydroelectric power generating equipment may require planning permission. The permissions needed depend upon the site. If the site contains, is within, or adjacent to a Scheduled Monument, Listed Building, Conservation Area, World Heritage Site, Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Ramsar Site (wetland of international importance), Special Protection Area (SPA), National Nature Reserve, Area of Outstanding Natural Beauty (AONB), or National Park, the relevant permissions will need to be obtained.

The local planning authority can grant permission under the Town and Country Planning Act 1990. They will be looking particularly for any issues regarding sustainability, visual impact and proximity to land boundaries. The National Planning Policy Framework (NPPF), published in March 2012, describes the aim of seeking positive improvement in the quality of the built, natural and historic environments. This requires an integrated approach to sustainable development that requires the conservation of 'heritage assets in a manner appropriate to their significance', whilst 'encouraging the use of renewable energy'. The NPPF and more information can be found on the DCLG website at www.communities.gov.uk.

You should engage in early pre-application discussions with the local planning authority and their statutory consultees. This will allow you to understand from an early stage what drawings, reports and investigations you may need to provide to give the planning authority a sound basis upon which to understand and determine your application. Moreover many potential pitfalls, costs and conflicts can be addressed through negotiation before any applications are submitted. As a starting point it is useful to draw the proposed installation on a photo of the suite or building in order to help the Planning Officer and other professionals visualise it in its proposed setting. This might include any distribution pipes, cables or ductwork that will be visible. Information on the historic significance of the site and the buildings upon it, along with an impact assessment, including any risk mitigation strategies may also be required.

Listed Building consent will be needed for all work that involves alteration, extension or demolition of a listed building affecting the character as a building of special architectural or historic interest. Contact the local planning authority to apply for Listed Building Consent.

Work of any kind to a Scheduled Monument requires consent from the Secretary of State under the Ancient Monuments and Archaeological Areas Act 1979. This can be applied for through English Heritage.

Further information on consents, and information on scheduling and listings can be found on the English Heritage website at www.english-heritage.org.uk.

There may be a more general archaeological impact which will need to be assessed and mitigated. When sites of this type are encountered, it is common for conditions to be attached to approval. For example, pipes and cables may need to run in certain locations, be hidden or exposed, be fabricated of certain materials etc.

As well as planning permission, different types of licences and consents may need to be gained. For example, there may be aquatic life within the stream or river. Where fish use the part of a river or stream in which the hydroelectric plant is proposed, a fish bypass can be built next to the weir. Additionally in some locations individually protected species may need to be considered. More information on these stipulations, such as abstraction licences, impound licences and land drainage consents can be obtained from the Environment Agency.


Weir and fish run (Dulas Ltd)


Fish run (image courtesy of Potential Energy)

CHOOSING AN INSTALLER

It is high standards of workmanship by thoughtful installers that make the difference between a project being good, and being excellent. Prospective installers should be asked very detailed questions about how they would approach the particular installation: for example, exactly where cables would run, and how they would be fixed. It should be possible to view examples of the installer's previous work, which will give you an indication of whether they are the right company to meet your particular needs.

It is safest to choose installers with experience of historic buildings, and certified by the Microgeneration Certification Scheme (MCS): a list of these can be found on the MCS website at www.microgenerationcertification.org.

The materials used will have an enormous impact on the end result, and on the overall suitability of the project. Special considerations may be needed for environmental reasons, or to ensure animal and plant life are not adversely affected: for example, ensuring cementitious material does not enter water courses.

It is important to take into account what effects the scheme may have on the surrounding landscape, archaeology, flora and fauna, and on existing services such as underground cables. A desktop archaeological study forms the basis of understanding on an historic site and may need to be augmented with survey work, trial excavation and opening up of fabric to evaluate impacts and inform the specification and consent of works. To prevent harm or mitigate loss, a programme of archaeological investigation, supervision and recording may be required and this will need to be proportionate to the impact of the works on the significance of the assets and their importance.

The physical process of the installation of a hydroelectric scheme must not be underestimated. Construction excavation can be messy, and will often require machines such as diggers to access the site. No construction excavations should start without the minimum of a desktop archaeological study.

The arrival of the turbine at Flatford Mill (Photo courtesy of MannPower)

Sites can be on steep slopes and in difficult to reach locations. Archimedes screw turbines are often delivered as one unit necessitating machinery to lift them into place. In remote locations, it may be necessary to delivery some materials by helicopter. Where the construction materials can be stored may also be important. How much space they will need and whether they can get wet for instance, will make a big difference to the space the construction site will need.

Lifting the turbine over the building at Flatford Mill (Photo courtesy of MannPower)

MAINTENANCE

All renewable installations will require maintenance to ensure they remain reliable and efficient, but when planning maintenance regimes, it is important to remember that they will always include some risk to the building fabric, which must be managed in some way.

Risks to the building can be minimised by thoroughly planning the installation, maintenance and the removal of any equipment. The working life of a hydroelectric turbine is far in excess of 20 years, but the lifespan many of its constituent parts will be far shorter: many parts will need replacing during the lifetime of the installation. These replacement parts will need to be considered when calculating the payback period (see Costs and Grants). Regular inspections of the condition of cables and equipment are usually necessary. Depending upon the system size, training can be given on system maintenance, or often a maintenance company is employed to look after the system. It is important to find out from prospective installers precisely which items will need regular maintenance, how often equipment will need replacing, and how the equipment will have to be accessed.

Effective maintenance, rather than repair is the recommended approach. The maintenance regime will be entirely dependent on the particulars of the installation, so manufacturers' recommendations and other expert advice should be followed.

Sluice gates over a coanda screen (Bilfinger Water Technologies Ltd)

As a guide, an expected outline minimum maintenance regime is;

DAILY
A visual check of safety equipment, grilles, etc. should be conducted.

WEEKLY
Ensure system not clogged with debris. Clean trashrack when needed.

MONTHLY
Grease bearings where appropriate, tighten belts, check water level in batteries, servicing, spare parts and maintain inlet channel and weir. Clean installation where possible.

ANNUALLY +
Clean out silt, weeds, and so forth in civil engineering works, repair any leaks or deterioration. Ensure transmission line is in good condition. Replace batteries every five to ten years, depending on quality and cycling patterns anticipated. Check land leases and permissions, validity of licences, level of electricity consumption and generation and any other costs e.g. insurance.

Coanda screen (Photo courtesy of Dulas Ltd)

04 Costs and Grants

As long as several years of measured flow data exist for the site, the output of an effectively maintained hydroelectric plant can be closely predicted. The economics of a hydroelectric scheme should be determined with a reasonable amount of certainty at the pre-feasibility stage.

The total costs for a project can be broken down into:
- civil costs,
- grid connection costs,
- electro-mechanical equipment costs,
- engineering and project management fees,
- ancillary costs, permissions etc.

In most projects around 75% of the total project cost will be the civil costs.

It is very difficult to predict how much a particular project will cost, since this will depend so greatly on constraints peculiar to the site. Low-volume, high-head systems are generally cheaper than those with low head and high volume, because the equipment will be smaller. If part of the system exists already, such as an appropriate weir, the civil costs can be reduced. This is one reason why installations in traditional sites are often desirable.

Ancillary costs should not be forgotten. These include legal fees, obtaining permissions and licences, transportation, and construction, as well as the pre-feasibility and feasibility studies.

There is a wide variation in the charges levied by different companies: a pre-feasibility study, for example, should take 2-3 days and will cost anywhere from £300 to £3000. Companies will generally specialise in projects of a particular size, so approaching a number of different companies is recommended.

Pre-feasibility studies are highly recommended, since there are many aspects which could prevent a scheme from being financially viable, so discovering problems at an early stage can save considerable amounts of money.

For smaller project, the pre-feasibility study will often be sufficient to allow the project to be planned. Larger projects (those over around 30kW) will usually to proceed onto a full feasibility study, which should cost between £5,000 and £10,000.

Loans and grants may be available to fund elements of the scheme. Grant eligibility can be dependent upon;

i. the Authority accredit an Eligible Installation as an accredited FIT installation if it is satisfied that the installation would receive accreditation under the Renewables Obligation Order (ROO), were an application to be made,
ii. in order for older installations to be eligible for the feed-in tariff, they must not have generated electricity since 31st March 1990 (otherwise old equipment will have to be remanufactured to become 'as new' (with a warranty), and re-installed by an MCS installer,
iii. applying for one grant or finance scheme can restrict you from getting another.

Grant Name	Description	Eligibility	Contact
FEED-IN-TARIFF	This is a financial incentive in the form of money paid by the government for every unit of electricity produced. The value given per kWh produced depends upon the size of the installation. The tariff is paid for a 20 year period.	Must be applied for through the ROO-FIT mechanism. Receipt must be made of the relevant licences and consents.	A registered FIT licensed supplier (list on Ofgem website)
SALIX FINANCE LTD	Interest-free loans for energy efficiency projects in the public sector	Schools, local authorities, NHS, further and higher educational institutions, police and fire services	Salix Finance Ltd.
ENHANCED CAPITAL ALLOWANCES (ECA)	Accelerated tax relief for businesses and organizations on equipment eligible for the ECA	The full eligibility criteria can be found on the DECC website	DECC
THE CARBON TRUST IN COLLABORATION WITH SIEMENS	Services of all kinds including financial (loans etc)	Organisations of all types	Siemens Financial Services

Correct at time of publication

05 Glossary

Abstraction licence
A licence issued by the Environment Agency, required where water is being taken from a water source.

ac (alternating current)
Electricity supply where the flow of current changes direction periodically. This is the type of electricity that is used in the plug sockets in your house.

Actual power
The maximum amount of power that can be generated on a site determined by the theoretical power multiplied by the efficiency of the specific hydroelectric generation scheme.

Battery bank
A number of batteries connected together to hold power for extended period of time.

Civil infrastructure
The manmade hard landscaping type features: bridges, weirs, concrete etc. to which the mechanical and electrical parts are fixed.

dc (direct current)
Electricity supply where the flow of electricity is in a single direction. This is the type of electricity that comes from batteries.

Earth bunding
Earth banked up above exiting ground level.

Electronic load controller
Electronic controls that ensure power generated is used in the most efficient way.

Fish bypass
A section where fish can get past the turbine or weir without being killed or injured.

Geared down
Using gears or belts to alter a shaft spinning very fast to one spinning slowly.

Installed generating capacity
The total rated output of the hydroelectric scheme. This will be the maximum amount of energy that can be generated using the equipment installed.

Generator
The equipment that converts the energy from movement into electricity.

Grid connection
The electrical connection between the hydroelectric equipment and the National Grid.

Ground works
Digging etc. The process of putting in place the civil infrastructure.

Head of water
The vertical height between the intake and the turbine.

Hydroelectricity
Energy created by the movement of water.

Hydrological survey
A survey measuring flow rates over an extended period of time.

Hydropower
An expression for an entire hydroelectric scheme.

Hydro-resource
The potential for generating electricity from water in a location.

Horizontal axis water wheel
A water wheel with a horizontal shaft.

Inverter
A piece of electrical equipment that converts dc to ac.

Kinetic energy
The energy within moving things.

National Grid
The network of electricity cabling throughout the UK.

Net or two-way electricity meter
An electricity meter which records the amount of electricity travelling into a property, and out from a property.

Pattress
A base onto which an item can be attached so that fixings that do not permanently damage the building or structure can be used.

Penstock
The pipe feeding water into a hydroelectric turbine.

Potential energy
Energy stored within stationary objects due to their elevation as a result of gravity working upon them.

Theoretical power
The maximum theoretical power that can be generated on a site, determined by the head and volume flow rate of water.

Turbine
A bladed device which spins around when a fluid acts upon it.

Vertical axis water wheel
A water wheel with a vertical shaft.

Volume flow rate
The volume of water in passing through an area in a specified time interval.

06 Useful Contacts

RENEWABLE ENERGY AND CLIMATE CHANGE

Climate Change and Your Home **–** an English Heritage website designed to help you understand more about the potential impacts of climate change and ways to save energy if you own or manage an older home.

www.climatechangeandyourhome.org.uk

The British Hydropower Association
Unit 6B
Manor Farm Business Centre
Gussage St Michael
Wimborne, Dorset
BH21 5HT
Website: www.british-hydro.org

The European Small Hydropower Association
Renewable Energy House
Rue d'Arlon 63-67
B-1040
Brussels
Belgium
Website: www.esha.be

The Green Valleys Initiative (TGV Hydro)
CRiC
Beaufort Street
Crickhowell
Powys
NP8 1BN
Website: www.tgvhydro.co.uk

ENVIRONMENT AND WILDLIFE

Environment Agency
National Customer Contact Centre
PO Box 544
Rotherham
S60 1BY
Tel: 03708 506 506
Website: www.environment-agency.gov.uk

Natural England
Northminster House
Peterborough
PE1 1UA
Tel: 0845 600 3078
Website: www.naturalengland.org.uk

RENEWABLE ENERGY GRANTS

Salix Finance Ltd
25 Southampton Buildings
London
WC2A 1AL
Tel: 020 3043 8800
Website: www.salixfinance.co.uk

Ofgem
9 Millbank
London
SW1P 3GE
Tel: 0845 200 2122
Website: www.ofgem.gov.uk

Department of Energy and Climate Change
3 Whitehall Place
London
SW1A 2AW
Tel: 0300 060 4000
Website: www.decc.gov.uk

Siemens Financial Services
Tel: 01753 434476
Email: eef.sfs.gb@siemens.com

PLANNING GUIDANCE

Department for Communities and
Local Government
Eland House
Bressenden Place
London
SW1E 5DU
Tel: 020 7944 4400
Website: www.communities.gov.uk

ENERGY CONSERVATION

The Carbon Trust
Dorset House
27-45 Stamford Street
London
SE1 9NT
Tel: 020 7170 7000
Website: www.carbontrust.com

Energy Saving Trust
21 Dartmouth Street
London
SW1H 9BP
Tel: 020 7222 0101
Website: www.energysavingtrust.org.uk

Microgeneration Certification Scheme
Contact through the Energy Saving Trust or via their website; www.microgenerationcertification.org

INFORMATION ON HISTORIC PROPERTIES

Society for the Protection of Ancient Buildings
37 Spital Square
London
E1 6DY
Tel: 020 7377 1644
Website: www.spab.org.uk

07 English Heritage Local Offices

NORTH EAST

English Heritage
Bessie Surtees House
41-44 Sandhill
Newcastle upon Tyne
NE1 3JF
Tel: 0191 269 1200
E-mail: northeast@english-heritage.org.uk

NORTH WEST

English Heritage
3rd floor Canada House
3 Chepstow Street
Manchester
M1 5FW
Tel: 0161 242 1400
E-mail: northwest@english-heritage.org.uk

YORKSHIRE AND THE HUMBER

English Heritage
37 Tanner Row
York
YO1 6WP
Tel: 01904 601901
E-mail: yorkshire@english-heritage.org.uk

WEST MIDLANDS

English Heritage
The Axis
10 Holliday Street
Birmingham
B1 1TG
Tel: 0121 625 6820
E-mail: westmidlands@english-heritage.org.uk

EAST MIDLANDS

English Heritage
44 Derngate
Northampton
NN1 1UH
Tel: 01604 735400
E-mail: eastmidlands@english-heritage.org.uk

EAST OF ENGLAND

English Heritage
Brooklands
24 Brooklands Avenue
Cambridge
CB2 8BU
Tel: 01223 582700
E-mail: eastofengland@english-heritage.org.uk

LONDON

English Heritage
1 Waterhouse Square
138-142 Holborn
London
EC1N 2ST
Tel: 020 7973 3000
E-mail: london@english-heritage.org.uk

SOUTH WEST

English Heritage
29 Queen Square
Bristol
BS1 4ND
Tel: 0117 975 0700
E-mail: southwest@english-heritage.org.uk

SOUTH EAST

English Heritage
Eastgate Court
195-205 High Street
Guildford
GU1 3EH
Tel: 01483 252000
E-mail: southeast@english-heritage.org.uk

08 Acknowledgements

English Heritage would like to acknowledge the help of the following people and organisations in the production of this guide:

Text by William Marshall

English Heritage Building services Engineering and Safety Team (BsEST)

Illustrations by Catherine Thomas (CT) and Judith Dobie (JD)

Photographs provided by: Hugh Jones, MannPower Consulting Ltd, Bilfinger Water Technologies Ltd, Dulas Ltd, Potential Energy Ltd, Stephen Bartlett and Matthew Edgecombe.

Edited by : Jen Heathcote

Product Code : 51887

Design and Production by : Vincent Griffin

July 2014

Please do not print this document unless you really need to.

If you would like this document in a different format, please contact our customer services department on;

telephone: 0870 333 1181

fax: 01793 414926

textphone: 01793 414878

email: customers@english-heritage.org.uk

ENGLISH HERITAGE