## Technical Note TN680 (Revised) / May 2023

# Hydropower (small-scale)

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### Summary


- Small scale hydro is viable where;
  - A good resource is available and can be developed at reasonable cost
  - A scheme can be built within environmental good practice
  - A timely grid connection can be obtained at reasonable cost or a consistent local demand exists
- Ballpark site potential can be assessed without excessive outlay
- Planning permission and a CAR licence are required
- Capital costs are very site dependant
- Schemes are more viable where an on-site or local demand is served, especially of offsetting high energy bills.


### Introduction

Scotland's wet climate and mountainous terrain means it is well placed to make use of hydropower technology. Many farms and estates in the country have historic hydro installations and many more have installed new schemes in recent years. This technical note examines the opportunities for development of new small scale hydro projects by farms and rural businesses.

### Types of Hydro Scheme

Large hydro schemes often include a storage reservoir upstream of the intake which acts as a buffer, allows the output of the turbines to be altered to match the demand for electricity and enables energy to be stored by raising the level of the reservoir following rainfall events. Many small hydro schemes are "run-of-river" systems where water is used only when there is a suitable flow in the river and these schemes have no provision for storage. The turbine in this type of system will generally be sized on the mean flow of the watercourse or slightly above it. Flows in excess of this will bypass the intake and continue down the watercourse.

Pumped storage schemes utilise a storage reservoir but in these water can be pumped from the lower level back up to the reservoir using electricity from other sources and then released to power the turbine at times of high demand for energy.

**High-head** hydro schemes are those with a head in excess of 50 m and utilise a relatively low flow of water for a given output. This type of scheme is common in the uplands of Scotland.

***Fig 1 Pipe laying for a small high head hydro scheme***

**Medium-head** hydro schemes (between 5 m and 50 m head) operate on the same principal as high head schemes but are likely to use different turbine designs.

**Low-head** hydro schemes rely on a large flow of water but may only have a head of a few metres. Low head schemes normally abstract water from immediately above a weir or waterfall and return it to the watercourse immediately below it. Opportunities to develop this type of scheme exist where there are existing weirs e.g. at the site of former waterwheels.

## Scheme viability

Three things are required for a viable scheme;

- An available resource that is economically developable.
- The possibility to develop the scheme in compliance with environmental good practice and regulation.
- A grid connection at reasonable cost or a local demand to match the electricity that will be produced.

## Resources

The potential capacity of a hydro power scheme is defined by the combination of the available head and available flow.

**Head -** is water pressure, which is created by the vertical height that the intake to the penstock pipe sits above the turbine.

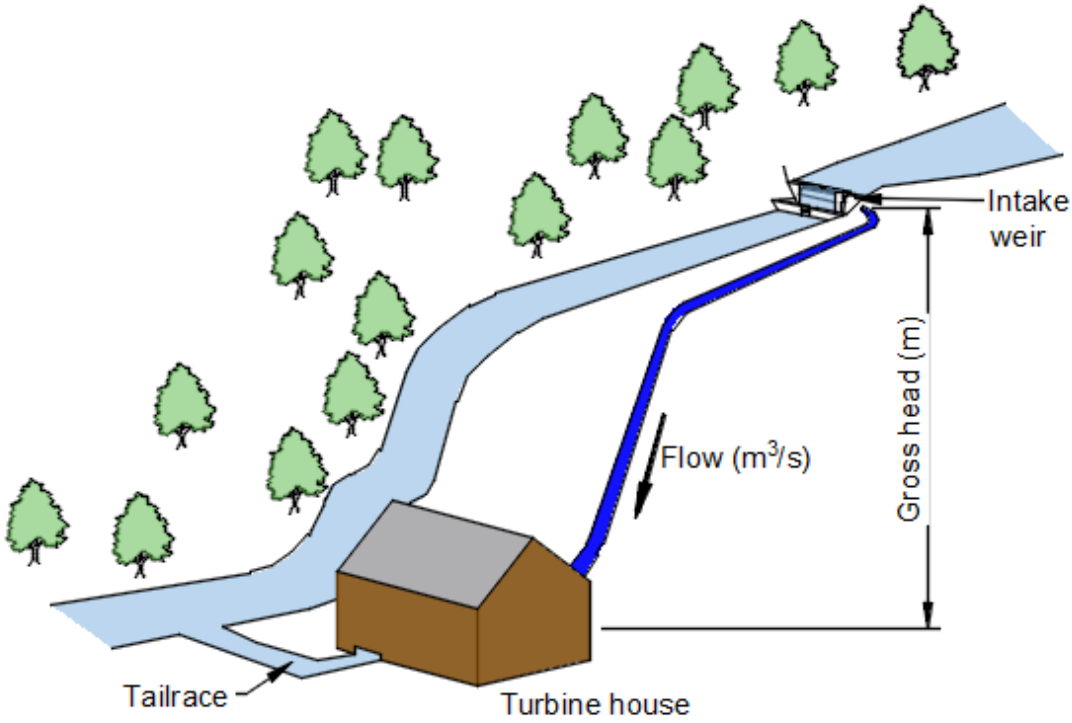


***Fig 2 Basic Run-of-River Hydro Scheme Layout***

**Flow** – the volume of water available to drive the turbine

Power available will depend on the head losses in the pipe and the mechanical and electrical efficiency of the equipment installed but if these two quantities are known a ballpark estimate of the potential capacity of a site can be calculated from the following formula;

Power (kW) = 7 x Flow rate ($m^3/s$) x Head (m)
(this assumes a water to wire efficiency of 70%)

i.e. a site with a head of 80 m and an available flow of 0.1 $m^3/s$ (100 l/s) could potentially support a 56 kW turbine.

**Available Flow** – The flow in the river or stream will depend on a number of factors including;

- The area of the catchment upstream of the intake location.
- The annual rainfall over this catchment.
- The physical characteristics of the catchment and vegetation cover, affecting the rate at which rainfall finds its way to the intake.

River flows can be measured on site over a period of months and then interpolated with long term data from a suitable gauging station to estimate the flow regime at the site. For smaller schemes the flow can be modelled using available long term weather data and information on the catchment characteristics.

Environmental considerations demand that a minimum quantity of water is allowed to pass down the depleted reach of the water course before any abstraction is allowed. An abstraction licence under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) is required for a hydro site. The following document from Natural Scotland and SEPA provides guidance on the necessary criteria for a scheme to be capable of obtaining consent:
https://www.sepa.org.uk/media/383805/guidance-for_developers_of_run_of_river_hydropower_schemes.pdf

*Fig 3 A 50 kW turbine and generator at a high head site.*

## Land Ownership/Development Rights

It is important to establish at an early stage that ownership of all of the affected reach is known and that development rights are clearly established prior to committing time and finance to developing a scheme.

## Planning permission

Planning permission will be required for a hydro scheme and early consultation with the local planning authority is advised. Beyond the construction phase, many run-of-river schemes will not be particularly visible in the landscape but the effect on local flora and fauna and on the water environment will need to be carefully considered. A screening opinion should be sought from the local planning department in respect of the Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011. Schemes of 500 kW or less may not require a full EIA unless there are site specific environmental concerns. However even where a full EIA is not deemed necessary the following issues should be addressed at the planning stage;

- Fish and fish habitat
- Protected species
- Bryophytes
- Morphological characteristics

- Built heritage
- Landscape
- Recreational use of the watercourse
- Trees
- Areas of deep peat

## Grid Connection

The cost of connecting a hydro generator to the electricity network can be considerable for a remote site where a distance of new overhead line or underground cable is required. Many areas of Scotland also have constrained networks already operating at their design capacity and access to the network may require extensive upgrading to the local distribution network or the national transmission network. This can not only add huge costs to a potential project it can also result in substantial time delays (often of several years) before a new generator can be connected. Liaison with the local network operator at an early stage is advised. In order to ensure that a connection will be available when required, it is necessary to have received an offer of connection, including a connection date and have paid a deposit to secure the grid capacity.

## Local Demand

Where a local energy demand exists, the income gained from a hydro scheme can often be enhanced, either by offsetting purchased electricity, or by receiving a higher payment from a local customer than that available by feeding power into the grid. Careful examination of the demand profile of the customer with the estimated yield profile of the scheme will allow the financial benefits of this arrangement to be assessed and inform a decision on how best to arrange a customer connection.

Where grid constraints apply and a local demand exists, a scheme with no or limited export connection may still be financially viable. Battery technologies or the generation of hydrogen are also developing areas that can help to make the most use of your renewable generation.

## Revenue and funding

With the removal of incentive schemes such as the Feed-in-Tariff (FIT), the main drivers for small-medium farm scale renewables are to provide security against volatile energy markets, offsetting grid bought power and providing green opportunities from becoming more energy self-sufficient. Inflated energy prices can also help significantly lower the payback periods for farm renewables.

Income from a hydro scheme can be derived from the following sources;

- Sale of exported energy – either from a power purchase agreement (PPA) or from export tariffs such as Smart Export Guarantee (SEG).
- Savings on imported energy – energy used on site to offset imported energy will normally provide a greater saving than the export rate available.

For more info on SEG and other government schemes see:
https://www.ofgem.gov.uk/environmental-and-social-schemes

Banks and financial institutions may offer favourable rates for loans on renewable and green projects. Further support may be available through schemes such as Business Energy Scotland, who offer a SME Loan and other cashback options.

More info on Business Energy Scotland can be found here:
https://businessenergyscotland.org/smeloan/

## Budget Costs

Construction costs for hydro schemes are very site specific and some investigation work is necessary before a realistic estimate of construction cost can be made.

Construction costs will also vary over time due to changes in raw material costs and economic conditions, therefore it is advisable to shop around to get the best deal. Farmers may be able to reduce costs by carrying out some of the groundwork, pipeline installation and concrete or metalwork themselves, however, it is vital to ensure the scheme is constructed to an acceptable standard. This will also ensure the turbine works effectively and reduce environmental risk. Once installed, hydro units are deemed to be very reliable, so on-going maintenance costs should be low.

## Business Rates

Business rates in Scotland were reviewed in 2023, for the first time since 2017. Rateable value is not purely based on the size of the installation, as a number of other factors are taken into account. Once the basic parameters of a potential scheme are established it should be possible to estimate the likely rateable value. Hydro schemes could be eligible for relief which can result in a reduction in rates paid. The exact rates and reliefs can be subject to changes in government policy and legislation. To obtain accurate and up-to-date information on business rates for hydro schemes in

Scotland, it is recommended to contact the local assessor's office or consult with a qualified professional.

For more info on Renewable Energy Generation Relief see: https://www.mygov.scot/non-domestic-rates-relief/renewable-energy-generation-relief

## Carbon Savings

The carbon saving attributable to any renewable energy generator will depend on the generation portfolio of the grid electricity that is offset. The electricity grid is becoming greener all the time as more renewables contribute to our electricity demand, but fossil fuels are still a major source. In 2022 the mean $CO_2$ intensity of the UK electricity grid was 182g$CO_2$/kWh. A 50 kW generator with a load factor of 35% would therefore have resulted in CO2 savings of 27.9 tonnes of $CO_2$ in 2022.

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