Improving the Welsh Dairy Supply Chain

Hydro power for dairy farms

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Hydro power for dairy farms
For a small number of farms fortunate enough to have a significant watercourse near to an electricity connection, hydro power can provide a cost effective and high output renewable generation facility.

Many streams and rivers have the theoretical potential to produce hydro-electric power. However, there can be many issues limiting the development of a small hydropower scheme, ranging from environmental and planning issues to grid connection restrictions and building practicalities.

Hydro turbines can have a useful lifespan of more than 50 years and have a relatively low environmental impact. They are generally low maintenance systems with efficiencies of over 70% often achieved.

Potential power

The power available from a water course is dependent on the head and the flow: the head being the vertical distance between the water levels at the intake and the outlet of the turbine feed, and the flow rate is the amount of water flowing in the river/stream. The latter will vary seasonally depending on the type of catchment and rainfall patterns.

A hydro scheme is usually allowed to take between 25% and 75% of the river flow. In England and Wales this figure is determined by the Environment Agency (EA), through the issue of a Water Abstraction Licence. For mountain streams with a land gradient of 10%, the highest abstraction rate is 70:30, meaning that 70% of the above average flow of the water may be taken out.

Potential power output can be estimated as follows:

Peak power output (kW electrical) =

head (metres) x average flow rate (m^3/second) x 9.81m/s^2 (gravity) × 0.6 (turbine efficiency at 60%)

Example: A turbine set with a 10 metre head with 0.2 cubic metres per second flow would produce:

10 × 0.2 × 9.81 × 0.6 = 11.77kW

You could also conduct a similar calculation using buckets to measure flow rate:

Peak power output (kW electrical) =

$$\frac{\text{Head (metres)} \times \text{average flow rate (buckets per second)}}{10}$$

Example: A stream with 50m of head with a flow of two buckets per second will give peak power of 10kW, generating 40,000kWh per year and earning up to £10,000 per year through the Feed-in Tariff scheme (based on a head over 20m and a 15 litre bucket). (Information provided by TGV Hydro.)

Yearly output will depend on seasonal conditions, but an average full power equivalent of 30% to 50% (load factor) might be expected. A 12 kW machine at 40% load factor would produce about 42,000 kWh of electricity. Calculations are usually based on the turbine running for 24hrs per day for approximately 80% of the year on average.

Types of turbine

Turbine type is determined by the flow and head pressure required with some types suiting high flow and others high head pressure. The main types of turbine are:

- **Reaction type - Francis or Kaplan turbine**
  Design is similar to a centrifugal fan and is suitable for most head pressures between 10m and 50m where the turbine rotor is fully immersed in water within a pressurised casing.

- **Impulse type - Pelton wheel or Turgo turbine**
  Similar to a paddle wheel but driven by a high pressure jet stream. This type of turbine is suitable for high head systems of above 30m.

- **Gravity type - Archimedes Screw**
  Looks like a giant grain auger and suitable for handling large volumes of water at very low head pressure, usually below 10m – but below 2m in some cases.

- **Steffturbine**
  This type of turbine is relatively new to the UK market but it is similar in principal to an old fashioned paddle wheel. The Steffturbine is positioned above the surface of the water and requires very little civil construction work, keeping installation costs down. It is suitable for high volume – low head applications (2-4m head and 100-400l/s flow rate).

Source: Sewaco Limited - www.sewaco.co.uk

Things to consider

Intake

Some diversion or damming of a water course may be required so it's necessary to assess the likelihood of flooding and to take into account fish mobility and screening. Building in wet areas such as within and near water courses brings practical challenges.

The intake weir usually consists of a screen and an integral box and a forebay tank. From here the water is channelled along pipework to the turbine.

Natural Resources Wales (NRW) would need to be informed of what impact a hydro scheme would have on the depleted reach, which is the difference between where the water intake is located and where the water returns to the river or stream.

Penstock

This is the pipe line which feeds water from the river to the turbine. To obtain the required head, it can be quite long, and it must be sized to give the right volume flow and have the appropriate pressure rating. Materials can be a range of plastics and metals.

Control

This is the system which starts, stops, operates and monitors the generator. These range from simple governors to complex computer based systems monitoring many variables (pipe pressures, bearing temperatures, cabinet temperatures etc.) and providing remote monitoring, control and fault finding and management.

Generator house
This contains the turbine, generator and control equipment and must be constructed with due regard to planning, visual impact, noise and flooding.

Grid connection
This is often a major cost. Generators invariably need a local three phase connection, although for very small systems a single phase connection may suffice (under 15kW). If there is a transformer within about 250m of the generator, it might be possible to connect a low voltage cable back to that point. Greater distances will involve the routing of a new high voltage supply and the installation of a new transformer and low voltage service.

Feed-in Tariff rates
The Feed-in Tariff rates for hydro schemes for April 2014 to March 2015 are set out in the table above. You must also add the value of energy exported and/or value of energy 'displaced' (energy which would have had to be imported from the grid) to this total.

Size Range	FiT Rate (p/kWh)
<15kW	21.12p
15kW to 100kW	19.72p
100kW to 500kW	15.59p
500kW to 2MW	12.18p
>2MW	3.32p

Costs
Average hydropower setup costs can range from around £80,000 - £150,000 for small scale run of river schemes, or between around £5,000 - £8,000 per kW of installed capacity. Between 60% and 80% of the total costs can be taken up by the civil work with only about 10% of the total cost attributable to the turbine.

For further information on hydro schemes please visit the British Hydro Association website: www.british-hydro.org.