Australian Government
Department of Industry

Dairy Australia
Your Levy at Work

Fact Sheet: Your Levy at Work

Hydro power for dairy farms

Hydroelectricity can provide a reliable form of renewable energy for dairy farms that are near a river or permanent creek with sufficient flow and fall.

Unlike commercial hydroelectric stations, small-scale hydro power systems do not require large volumes of water to be held in dams. They are usually 'run of the river' systems that allow river or creek flow to continue, reducing the environmental impact of the plant.

The small-scale systems are often divided into three categories, depending on the output of electricity:

- **micro-hydro** – produces less than 100 kW
- **mini-hydro** – produces from 100 kW to less than 1 MW
- **small-hydro** – produces from 1 MW to less than 10 MW

Hydraulic head and flow rate

The advantage of hydro power over other renewables is that a permanently flowing creek can produce power continuously.

The amount of electricity that can be generated depends on the hydraulic head and the flow rate of the water. The greater the head and/or the flow rate, the more power will be produced.

Hydraulic head is the vertical distance through which the water falls from the source to the turbine elevation (static head) minus the frictional loss on its path (frictional head).

The hydraulic head is independent of the horizontal distance, but the frictional loss increases with horizontal distance.

A drop of at least one metre is required for a micro-hydro system,[1] although a hydraulic head this small would require a very large flow rate to produce a meaningful amount of energy. The amount of head can be measured using a dumpy level, a contour map or by attaching a pressure gauge to a water pipe installed at the site.

Flow rate is the quantity of water that is falling measured in litres per minute (L/min) or per second (L/s). Flows as low as 8 L/min (0.13 L/s) are sufficient to produce small amounts of electricity.[1] Flow rate can be measured by timing how long it takes to fill a 10 litre bucket with water falling from a narrow opening or a pipe. Alternatively, a float can be placed mid-stream in a channel and its travel downstream timed over a defined distance. Flow rate can be calculated once the area of a cross section of the stream is determined.

Flow rate (m^3/s) = velocity of water x cross-sectional area of stream x correction.

NB – Divide the flow rate by 1,000 to get litres per second (L/s).

Velocity (m/s)	Time a float along a straight section of the stream. Repeat several times and take the average.
Cross-sectional area (m^2)	Measure the width and depth at several points along the same section of the stream. Area = width x depth. Again, take the average.
Correction	Depends on the surface of the stream bed [3] Smooth stream bed = 0.9 [3] Rocks, twigs and weeds on stream bed = 0.8 [2] Rough hill stream = 0.5

Components of a hydro power system

The components in a hydro power system will depend on whether it is designed to feed power back into the mains grid or is stand alone.

All systems have the following components in common:

- **Diversion and settling pond** – directs water from the river or creek and allows any mud to settle
- **Penstock** – the pipeline or channel down which the water flows to the turbine
- **Intake screen** – channels water into the penstock while filtering out floating debris
  Turbine – converts the kinetic energy of falling water to mechanical energy
- **Generator** – generates electricity, this can be DC (small) or AC (large)
- **Inverter, load bank or induction generator** – regulates the energy produced to match it to load requirements
- **Wires** – transmit electricity from the hydro power system to the equipment that is drawing the load.
- **Meter** – measures the amount of power produced by the hydro power system.

Grid feed systems need a special grid-interactive inverter and special meters. Stand-alone systems require deep cycle batteries to store surplus electricity and a control system to prevent the batteries overcharging or completely discharging.

How do hydro power systems work?

Water is diverted from the main current into a settling pond.

A grill at the intake of the penstock screens out floating debris.

The water flows down the penstock to the turbine where the kinetic energy of the flowing water is turned into mechanical energy by the rotating turbine.

The water leaves the turbine and is returned to the main flow of the creek or river.

Some turbines do not need a penstock and are positioned in the stream itself.

The electricity produced may be regulated through a load bank, which dissipates any energy that is not required. Alternatively, an induction generator maybe connected to the turbine to produce alternating current.

Some hydro power generators are connected to an inverter, which converts the direct current produced to alternating current at 240 volts.

Figure 1.

Types of hydro power systems

Hydro power systems are divided into three categories:

- High-head (a fall of more than 20 metres) systems use the large amount of potential energy stored at the top of the penstock and can produce power with low flow rates.
- Medium-head (10 20 metres) systems require a bigger volume of water and higher flow rate than high-head systems to produce the same amount of power.
- Low-head (less than 10 metres) systems need high flow rates to compensate for the loss of potential energy with the loss of head.

The following chart shows the relationship between head and flow rate needed to produce 5 kW of electricity from a hydro power system working at 75% efficiency.

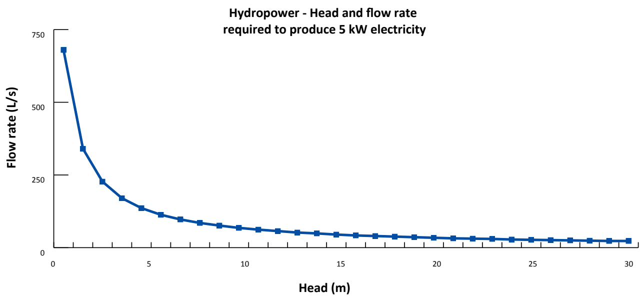

Figure 2. Head and flow rates

There are several types of turbines that can be used in hydro power systems. In general, impulse turbines spin in the air when a high pressure jet of water is trained on the blades; reaction turbines are fully submerged and rotate as the water flows past them.

Turbine Type	Example	Head	Features
Impulse	Pelton	High	Invented in the 1870s and still one of the most-efficient turbines.
Reaction	Francis	Medium to high	The most common water turbine in use today.
Propeller	Kaplin	Low to medium	Developed from the Francis turbine for low-head applications.
Cross-flow	Banki	Low	Low-cost turbine that self cleans and is less prone to jam with debris.

Site requirements

If you are thinking of installing a hydro power system, you need to have answers to the following questions:

1. Does the farm have a permanent creek or river?
2. Is there sufficient head and flow to meet some or all of the farm's energy requirements?

3. Does the terrain allow a settling pond and penstock to be constructed?
4. Does the terrain allow access to the site for construction and maintenance?
5. How far is the site from the dairy?
6. How common and severe are droughts in your area?

Also, consider the water source: it may have sufficient head and flow rate, but be remote and difficult to reach. Theoretically, electricity can be transmitted across any distance but there is a loss of voltage and power as the length of the wires increases. The greater the distance from the site to the dairy, the higher the power production needed to compensate for this loss.

Supply, installation and maintenance

Several Australian companies supply and install hydro power systems on farms. They also provide technical advice and site assessments. The systems come with a set of maintenance instructions that should be read and followed.

Power production

Although hydro power systems can run with very small heads and flow rates, the amount of power produced is also very small. A head of 10 m and a flow rate of 70 L/s are required to produce 5 kW of electricity. Doubling the head to 20 m or the flow rate to 140 L/s will double the power output.

These figures allow for a turbine-generator efficiency of 75%. Both turbines and generators vary in their efficiency from about 50% to 80%, depending on the type and set up.

Drags on hydro power's potential?

- **Stream capacity** – The maximum power output from a creek or river is fixed by its head and flow rate.
- **Variable flow** – Most creeks and rivers have a variable flow depending on the season and rainfall. This will affect the quantity of power produced.
- **Friction loss** – As water flows down the pipe or pen stock energy is lost due to friction. The amount of friction reduces the effective head of the system.
- **Inverters** – Some of the power produced by the hydro system is needed to run the inverter.
- **Transmission** – Electricity is lost as it is transmitted along wires. The greater the distance, the greater the loss.

Costs

The average hydro power turbine and generator costs about one-tenth of a solar PV unit of equivalent output.[4] A 5 kW hydro power unit may cost around $1,500 before rebates.

Other costs may need to be taken into account. These include construction costs for the settling pond and penstock, the cost of pipe or channel for the penstock and poles and wires or underground cabling to transmit the power to the dairy.

Renewable energy incentives

Hydro power systems with a power output of no more than 6.4 kW that produce less than 25 MWh of electricity each year are eligible for a financial incentive under the Small-scale Renewable Energy Scheme (SRES).

If the system is larger, it will be classified as a power station and will need to be accredited in order to be eligible. Each MWh of renewable electricity that can be produced by the system creates one small-scale technology certificate (STC). These STCs have a dollar value that is paid for the energy produced over a 15-year period. STCs can be traded, usually to the company supplying the system, for a reduction on the initial purchase cost.

For more information on renewable energy incentives,refer to the fact sheet 'Renewable energy incentives'.

Dairy farmers who connect their hydro power systems to the grid will also be paid for electricity that they feed into the grid. For more information refer to the fact sheet 'Feed-in tariffs'.

Does hydro power suit dairy farms?

For dairy farms with a permanent creek or river flowing through suitable terrain, hydro power may be the most cost-effective form of renewable power to meet at least some of the dairy's energy needs.

The average 220 cow-dairy in Australia consumes 70,000 kWh of electricity each year, with a daily use of about 200 kWh. This load is concentrated during morning and afternoon milkings and while the milk is cooling, when more than 20 kW required each hour.

A micro-hydro plant producing 10 kW would need a head of 10 m and a flow rate of 136 L/s. This is equivalent to the small waterfalls that are not uncommon in the high-rainfall hinterland areas of the east coast of Australia and in many parts of Tasmania.

A 2 kW DC micro unit will cost around $3,000 plus around $6,000 installation, but will produce 48 kWh per day.

An advantage of hydro power over other renewable sources is the continuity of supply. Power is produced 24 hours a day, seven days a week. Surplus energy can be stored either in the settling pond by switching off the turbine or in batteries.

Battery storage is expensive, although the technology is improving.

In grid-connected systems, electricity can be fed into the grid when there is a surplus and 'borrowed back' when it is needed. However, to allow for the capital cost of installing the hydro power system, this is only cost effective when the feed-in-tariff is greater than the cost of mains power.

An alternative is to consider electricity production from a hydro power system as a separate farm enterprise and a means of diversifying farm income. Again, site suitability, purchase and installation costs, the cost of finance, available rebates, feed-in tariffs and the pay-back time would all need to be investigated thoroughly before an enterprise of this nature is considered.

Advantages of hydro power

- Continuous supply of electricity
- Low flows and head can still generate electricity
- No reservoir required – low environmental impact
- System purchase costs much lower than for other renewable sources
- Low maintenance requirements

Disadvantages of hydro power

- Many dairy farms do not have suitable water sources and terrain
- Requires structural changes which may be costly
- Greatly affected by rainfall or snow
- Power production limited by the capacity of the available water resource
- Expansion may not be possible as power demand increases
- Floods can damage the turbine and generator.

Conclusion

Hydro power is a cheap source of renewable energy per kW installed, but it is also the most site-dependent source. A heavy and stable flow of water is needed before a hydro power system will become viable; even then, the system can be severely disrupted in times of flooding or droughts.

The energy output of a hydro system can be manipulated to match the load profile of a dairy, which means it can make use of the most cost-effective scenario and supply the dairy with a stable source of energy during the most expensive tariff times.

If the water is available, a micro-hydro system could be a viable way to reduce dairy farm energy bills.

References

1. UTS (2012) Micro-hydro power systems factsheet (draft). Institute for Sustainable Futures, University of Technology Sydney.
2. Pedal, P. (2004) Harnessing energy from nature (12th ed.) Rainbow Power Company, Nimbin.
3. eHow (2012) How to calculate stream flow. Demand Media, Inc. http://www.ehow.com/how_6697587_calculate-stream-flow-rate.html
4. Platypus Power (2012) Micro Hydro Electric Generator Factory. http://www.platypuspower.com.au/comquest.html.
5. UTS (2012) Solar photovoltaic (PV) systems factsheet (draft). Institute for Sustainable Futures, University of Technology Sydney.

Note

Information and technology is changing rapidly in this area. Make sure you consult an expert about your individual circumstances to see whether renewable energy is an efficient and economic option for your farm.

Further reading

Alternative Energy – Micro Hydro Power – Pros and Cons, posted in Environment, Hydro Power, http://www.alternative-energy-news.info/micro-hydro-power-pros-and-cons

Calculation of Hydro Power. http://www.reuk.co.uk/Calculation-of-Hydro-Power.htm

Energy Matters – Micro-hydro/Water power Systems. http://www.energymatters.com.au/renewable-energy/micro-hydro

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Practical Action. Micro-hydro power. http://practicalaction.org/micro-hydro-power.

Small Hydropower and Micro Hydropower. http://smallhydro.com

Small HydroPower Handbook. http://www.smallhydropower.com/manual3.htm#no6.

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Disclaimers

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