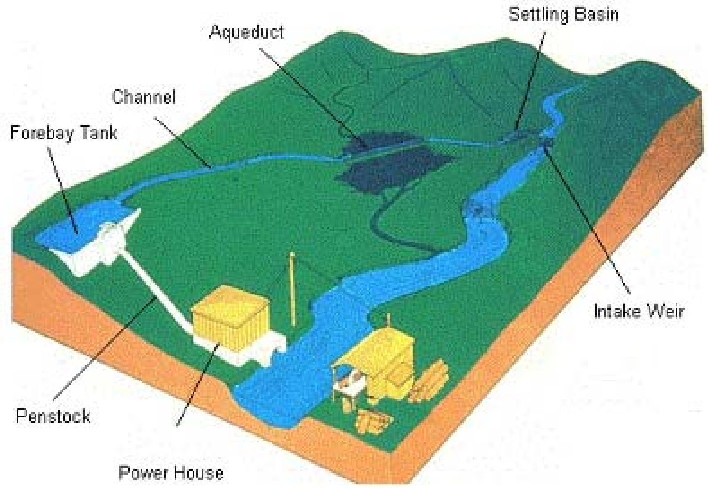
Micro-Hydro Power

Introduction

Hydropower is based on the principal that flowing and falling water has a certain amount of kinetic energy potential associated with it. Hydropower comes from converting the energy in flowing water, by means of a water wheel or a turbine, into useful mechanical energy. This energy can then be converted into electricity through means of an electric generator. The energy from the flowing/falling water can also be used directly by suitable machines to avoid the efficiency loses of the generator. Recently, small-scale hydropower systems are receiving a great deal of public interest as a promising, renewable source of electrical power for homes, farms, and remote communities. Micro-hydro systems refer specifically to systems generating power on the scale of 5 kW to 100 kW.

Background

The micro-hydro system includes a water turbine that converts the energy of flowing water into mechanical energy. This mechanical energy drives a generator which produces electrical power. The efficiency of the overall system, given the pipe friction loses and turbine deficiencies, is generally on the range of 50% of theoretical power associated with the energy of the flowing/falling water. Micro hydro has been in use for many years in many applications. It is used in foreign countries because of the relative ease of production of electricity when compared to the other options available. However, typical demand for micro-hydro by foreign countries tends to be much lower than the typical demand of the United States. The turbine used varies from site to site according to the given pressure head and design flow at each site. The elevation at which the river begins at is very important when evaluating the use of micro hydro as this difference in elevation is where the kinetic energy of the water is derived from. The below Figure 1 depicts a typical system and details the general components found at a micro-hydro facility.



LEGEND

Intake Weir - Located upstream to divert flow of water into the channel.
Channel - transports water from intake weir to forebay tank.
Forebay Tank - filters debris and prevents it from being drawn into turbine and penstock pipe.
Penstock Pipe - carries the water from forebay tank to the powerhouse.
Powerhouse - where turbine and generator convert waterpower into electricity.

Figure 1: Diagram of Typical Micro Hydro Usage

The theoretical power produced by a micro-hydro system depends entirely on the flow rate of the water, vertical height (or head) that the water falls and the acceleration of water due to gravity through the equation:

$$P = Q \times H \times c$$

Equation 1: Theoretical Power of the River

Where P is in units of watts, Q is the flow rate in m^3/sec, H is the head in meters and c is the product of the density of water and gravity in kg/m^3 and 9.81 m/s^2, respectively.

Case Study

The owners of a large 750 acre farm in Oregon decided that a micro-hydro project would be a great idea for their farm as they were located in a spot with two large natural lakes nearby and receive nearly 50 inches of rainfall annually. An engineer went to the site and completed a thorough assessment of the project and recommended a 20 kW micro hydro system. After a long process of dealing with twelve various public agencies for approval, the project was finally undertaken. A 14 by 16 foot powerhouse was built in order to house a twin turbine, single generator system which features a control system with automatic features. The entire initial cost of the project was roughly $100,000. From Oregon laws based on renewable energy, approximately $65,000 of the initial costs were eligible for a tax credit program and they received 35% ($22,750) of this credit spread out over the first ten years of the system. In addition to the tax audit program, the 175 acre portion of land where the system is located is exempt from property taxes. This system has a payback period of 18.5 years. Unlike other renewable technologies, the equipment used for micro-hydro power is extremely durable and is expected to provide power for at least a century with very little maintenance needed.

Where Micro Hydro Power is Feasible

Micro-hydro systems are only cost effective and an economical source of energy under certain conditions. The best areas for this type of system include steep rivers flowing all year round, areas of the country with high year round rainfall, or islands with moist marine climates. Flows of rivers and streams vary with season thus affecting the power output of the system proportionally. Water flow is greater around winter time, yielding higher output productions. Photovoltaic systems often are at their lowest point of efficiency during this time of year. Due to this occurrence, many micro hydropower systems are complimented with photovoltaic systems to balance out these deficiencies. There have been many advances in low head turbines and in the near future micro-hydro systems may become a more feasible option given less than ideal conditions.

Advantages of Micro Hydro Power

An advantage of a micro hydro systems are that once a system is in place it generates a predictable amount of power from the concentrated energy source of the water. The technology itself is one that withstands the test of time requiring little maintenance or new investments for years to come. Another benefit of this system is that no additional fuel costs are required. Thus micro-hydro systems are unaffected by varying price and demand for fuels as the water flow is constant and free.

Disadvantages of Micro Hydro Power

While there are several advantages to this alternative energy source, it has drawbacks as well. The biggest drawback with this system is that good locations where the power is needed are hard to come by. Also, those sites that are acceptable can require a large amount of initial capital. Other drawbacks include the existence of a maximum useful power output available per site which limits site expansion. As mentioned earlier, water flow rates vary seasonally and this can limit the power output at times when it is potentially needed most.

<u>References</u>

Figures and Tables

Figure 1: Diagram of Typical Micro Hydro Usage

From Arquin, M. (2006) http://www.kidwind.org/pdfiles/Wind%20Power%20Curvesv3.pdf

Equation 1: Theoretical Power

From microhydropower.net

Additional Information

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