MICRO-HYDROPOWER

NEED FOR ENERGY FOR RURAL DEVELOPMENT

Significant water resources are found in many developing countries. In areas where adequate water resources are present, harnessing the power of falling water by means of micro-hydropower plants is one way of providing affordable energy for the development of rural areas.

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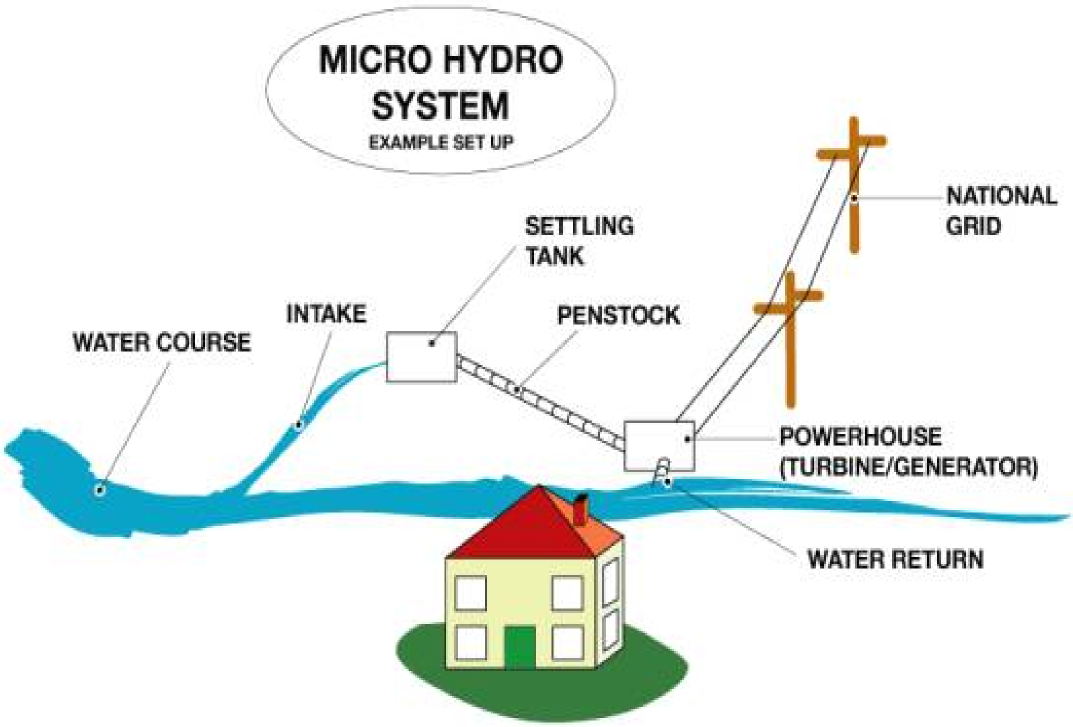
INTRODUCTION

In many developing countries, the large percentage of the population lives in rural areas, they have been deprived of the benefits available to those in the urban areas that result from these development activities:

- Extension and improvement of transportation and communications networks;
- Provision of electricity and water and their associated benefits;
- Construction of schools, hospitals, and clinics;
- Increased employment opportunities; and
- Access to agricultural and health extension services.

From an individual's point of view, the easiest means of acquiring these amenities is to migrate to the towns and cities, where these problems will be solved.

An energy source that can be viably implemented in a rural setting would contribute to the attractiveness of the rural areas.



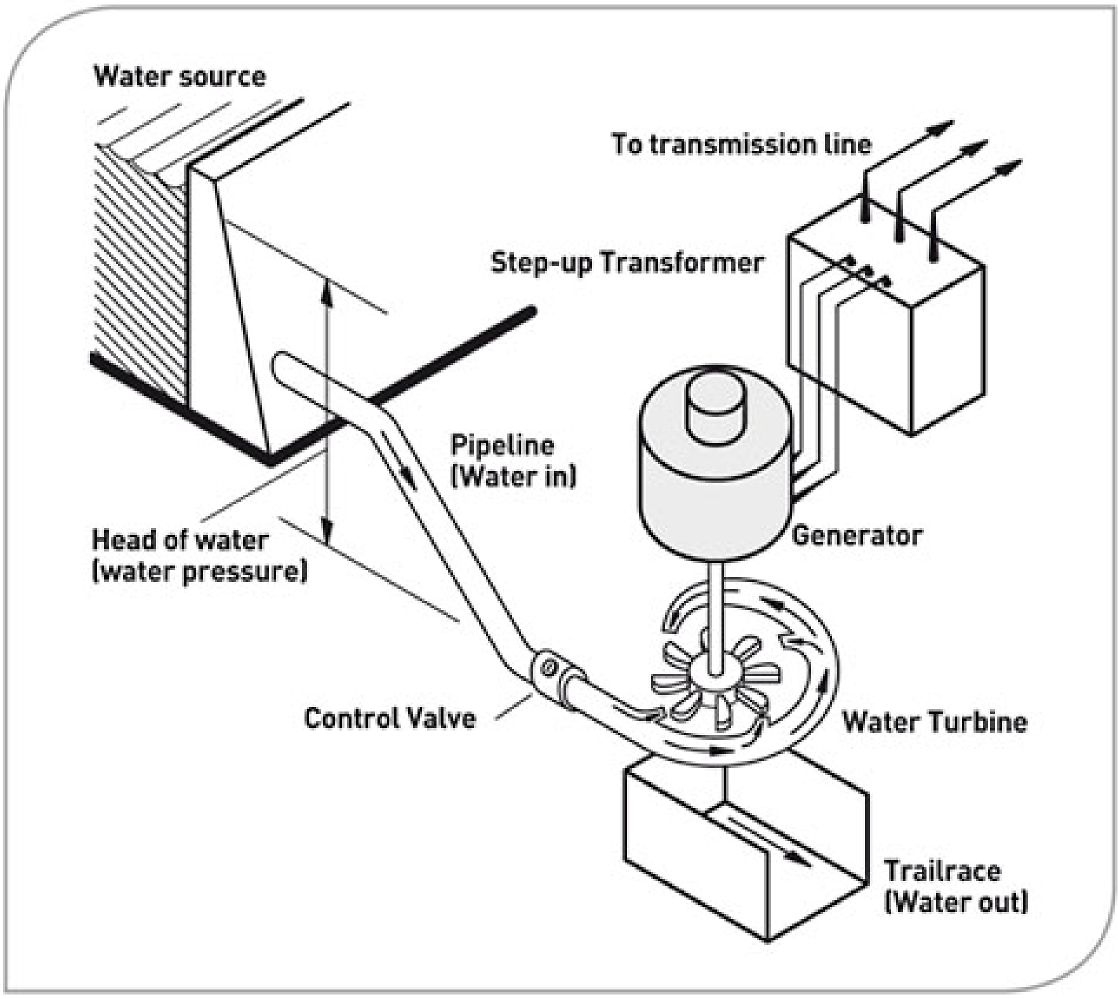
Electric power would encourage the establishment of government offices and associated services; provide an incentive for better trained persons to serve in the more remote areas; improve the quality of educational, health, and other services; an affordable source of electrical as well as mechanical and thermal energy could encourage the establishment of agro-processing and cottage industries, which would contribute to employment opportunities in rural areas, increased disposable incomes, and a decreased drain on a nation's foreign exchange spent on importing agricultural products.

Significant water resources are found in many developing countries. In areas where adequate water resources are present, harnessing the power of falling water by means of micro-hydropower plants is one way of providing affordable energy for the development of rural areas.

Principle of Micro-hydro power

Micro hydro power is the small-scale harnessing of energy from falling water. Hydraulic power can be captured wherever a flow of water falls. The vertical fall of water, known as the "head", is essential for hydropower generation (fast-flowing water on its own does not contain sufficient energy for useful power production). Hence, two quantities are required for production of hydropower: a **Flow Rate** of water and a **Head**. The capacity of a micro hydro power plant is usually between 20 and 500 kW *(Fig.1).*

Scheme of a micro hydro power plant



(Fig.1)

Micro-hydro power: An Appropriate ENERGY Source

Micro-hydro power has several advantages in common with large-hydropower schemes:

- It relies on a renewable, nonpolluting, indigenous resource that can displace petroleum-based fuels that are frequently imported at considerable expense and effort (*Fig.2)*.

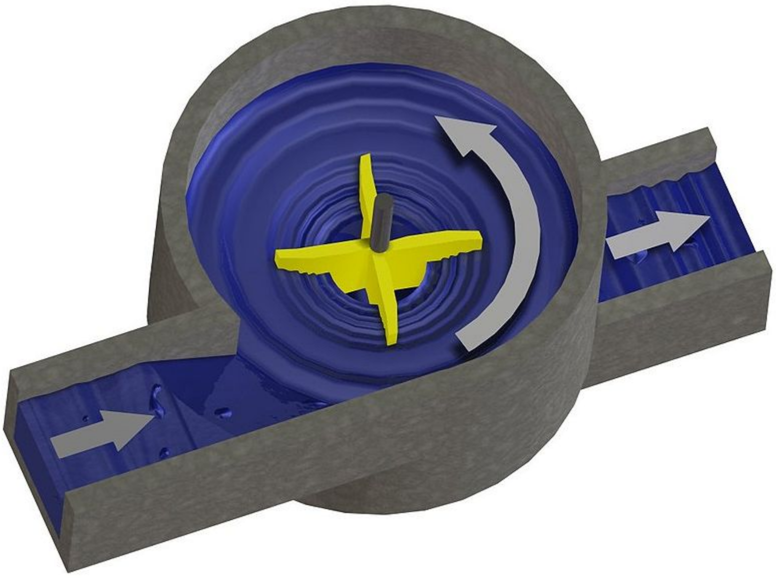
(Fig.2) (Because of the expense and difficulty of transporting fuel to remote areas, and the availability and knowledge of hydropower engines frequently lead to their use in remote areas).

- As a component of a water development scheme, it can be integrated with irrigation and water-supply projects to maximize the benefits while sharing the cost among several sectors *(Fig.3)*.
- It is a well-proven technology; generally well beyond the research and development stage. In addition, hydropower resources have already been harnessed for years by rural entrepreneurs and farmers in numerous Asian, African, and Latin American countries.

(Fig.3) (This micro-hydropower plant is integrated with an irrigation scheme, using excess water to generate power for a nearby town, thereby displacing the diesel fuel that would otherwise be used).

(Fig.4) (Micro-hydropower projects permit significant villager involvement in all phases of the work).

Micro-hydropower technology also has a number of positive attributes not usually associated with large-hydropower plants. One is that, because of their size, micro-hydropower schemes permit local villager involvement in the full range of activities, from initiation and implementation to operation, maintenance, and management *(Fig.4)*. When villagers contribute labor and local materials, the costs incurred are lower, and when villagers are committed to a properly planned and executed project, the possibility of its long-term success increases significantly.



(Fig.5) (Generating mechanical energy by Micro-hydropower projects).

In addition to generating electricity, micro-hydropower plants permit the generation of mechanical energy, which can be used to power agro-processing machinery or cottage industries directly. This permits the use of a less complex technology, which in turn is both less expensive and more easily understood. The increased efficiency of direct conversion to mechanical power, rather than using a generator and then motors to provide it, means that up to twice the useful power is available from a given turbine, depending on the size of the plant *(Fig.5)*.

Key Advantages of Small Hydropower Plants in general:

Hydropower is energy from water sources such as the ocean, rivers and waterfalls. "Mini-hydro" means which can apply to sites ranging from a tiny scheme to electrify a single home, to a few hundred kilowatts for selling into the National Grid. Small-scale hydropower is one of the most cost-effective and reliable energy technologies to be considered for providing clean electricity generation. The key advantages of small hydro are:

- High efficiency (70 - 90%), by far the best of all energy technologies.
- High capacity factor (typically >50%)
- High level of predictability, varying with annual rainfall patterns
- Slow rate of change; the output power varies only gradually from day to day (not from minute to minute).
- A good correlation with demand i.e. output is maximum in winter
- It is a long-lasting and robust technology; systems can readily be engineered to last for 50 years or more.

It is also environmentally benign. Small hydro is in most cases "run-of-river"; in other words any dam or barrage is quite small, usually just a weir, and little or no water is stored.
Therefore run-of-river installations do not have the same kinds of adverse effect on the local environment as large-scale hydro.

Suitable conditions for micro-hydro power:

The best geographical areas for exploiting small-scale hydro power are those where there are **steep rivers** flowing all year round, for example, the hill areas of countries with high year-round rainfall, or the great mountain ranges and their foothills, like the Andes and the Himalayas for example. Also Islands with moist marine climates, such as the Caribbean Islands, the Philippines and Indonesia are also suitable. Low-head turbines have been developed for small-scale exploitation of rivers where there is a small head but sufficient flow to provide adequate power.
To assess the suitability of a potential site, the hydrology of the site needs to be known and a site survey carried out, to determine actual flow and head data. **Hydrological information** can be obtained from the meteorology or irrigation department usually run by the national government. This data gives a good

overall picture of annual rain patterns and likely fluctuations in precipitation and, therefore, flow patterns.
The site survey gives more detailed information of the site conditions to allow power calculation to be done and design work to begin. Flow data should be gathered over a period of at least one full year where possible, so as to ascertain the fluctuation in river flow over the various seasons. There are many methods for carrying out flow and head measurements.

Hydro Power basics:

- ### Water into watts

To determine the power potential of the water flowing in a river or stream it is necessary to determine both the flow rate of the water and the head through which the water can be made to fall. The flow rates the quantity of water flowing past a point in a given time. Typical flow rate units are liters per second or cubic meters per second. The head is the vertical height, in meters, from the turbine up to the point where the water enters the intake pipe or penstock.

The potential power can be calculated as follows:

Theoretical power (P) = Flow rate (Q) x Head (H) x Gravity (g) (G= 9.81 m/s2)

When Q is in cubic meters per second, H in meters and g = 9.81 m/s2) then,

P = 9.81 x Q x H (kW)

- ### Head and Flow

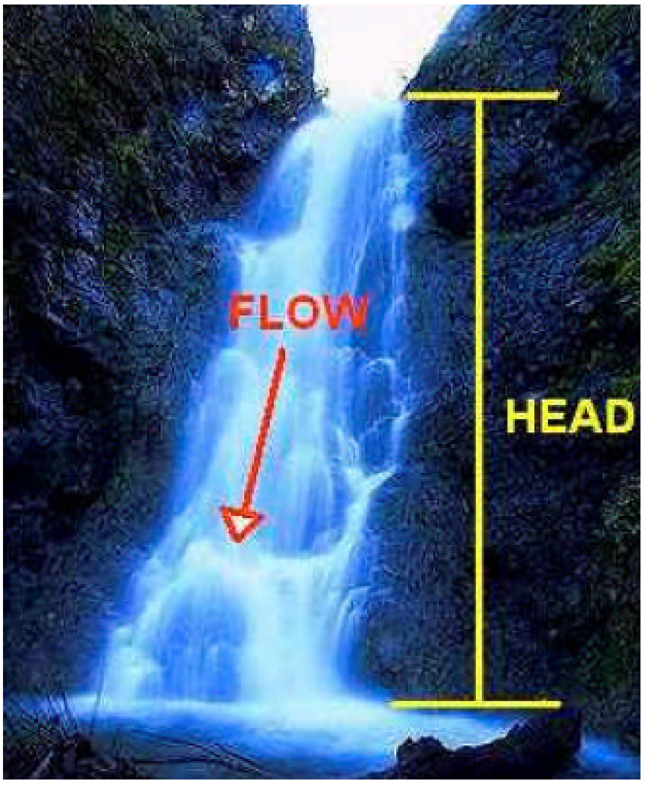
Hydraulic power can be captured wherever a flow of water falls from a higher level to a lower level.
The vertical fall of the water, known as the "head", is essential for hydropower generation; fast-flowing water on its own does not contain sufficient energy for useful power production except on a very large scale, such as offshore marine currents.

Hence two quantities are required: a Flow Rate of water **Q**, and a Head **H**. **It is generally better to have more head than more flow**, since this keeps the equipment smaller.

The Gross Head (H) is the maximum available vertical fall in the water, from the upstream level to the downstream level. The actual head seen by a turbine will be slightly less than the gross head due to losses incurred when transferring the water into and away from the machine. This reduced head is known as the Net Head.

Flow Rate (Q) in the river is the volume of water passing per second, measured in m3/sec.

For small schemes, the flow rate may also be expressed in liters/second or 1 m3/sec.



(Fig.6) (Head and Flow).

- ## Power and Energy:

Power is the energy converted per second, i.e. the rate of work being done, measured in watts (where 1watt = 1 Joule/sec. and 1 kilowatt = 1000 watts).
In a hydro power plant, potential energy of the water is first converted to equivalent amount of kinetic energy. Thus, the height of the water is utilized to calculate its potential energy and this energy is converted to speed up the water at the intake of the turbine and is calculated by balancing these potential and kinetic energy of water.
Hydro-turbines convert water force into mechanical shaft power, which can be used to drive an electricity generator, or other machinery. The power available is proportional to the product of head and flow rate. The general formula for any hydro system's power output is:

$$P = \eta \rho g Q H$$

Where:

- **P** is the mechanical power produced at the turbine shaft (Watts),
- **η** is the hydraulic efficiency of the turbine,
- **ρ** is the density of water (1000 kg/m3),
- **g** is the acceleration due to gravity (9.81 m/s2),
- **Q** is the volume flow rate passing through the turbine (m3/s),
- **H** is the effective pressure head of water across the turbine (m).

The best turbines can have hydraulic efficiencies in the range 80 to over 90%, although this will reduce with size. Micro-hydro systems (<100kW) tend to be 60 to 80% efficient.

Capacity Factor

'Capacity factor' is a ratio summarizing how hard a turbine is working, expressed as follows:
Capacity factor (%) = Energy generated per year (kWh/year) / {Installed capacity (kW) x 8760 hours/year}

Energy Output

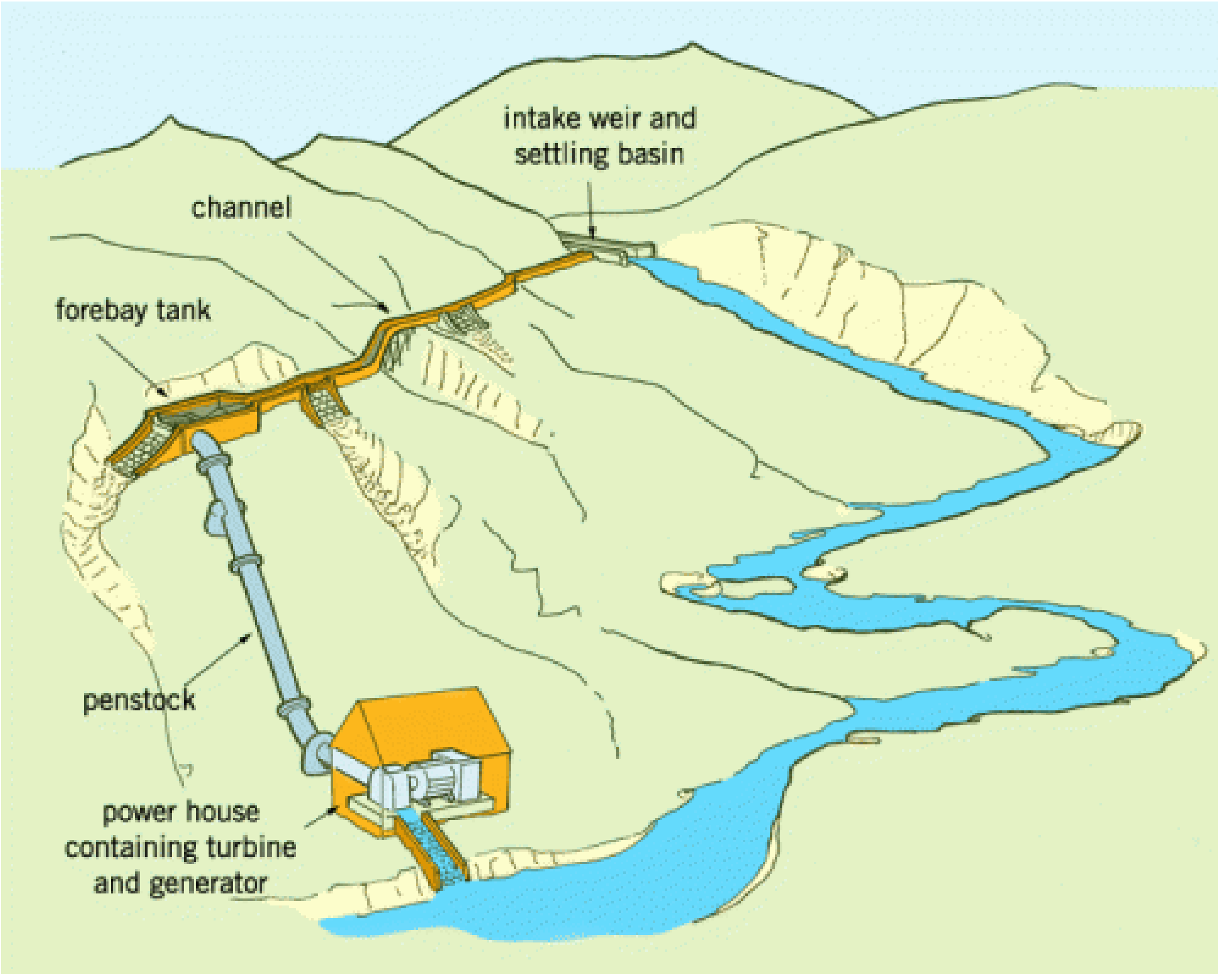
Energy is the work done in a given time, measured in Joules. Electricity is a form of energy, but is generally expressed in its own units of kilowatt-hours (kWh) where 1 kWh = 3600 Joules and is the electricity supplied by 1 kW working for 1

hour. The annual energy output is then estimated using the Capacity Factor (CF) as follows:
Energy (kWh/year) = P (kW) × CF × 8760

However, energy is always lost when it is converted from one form to another. Small water turbines rarely have efficiencies better than 80%. Power will also be lost in the pipe carrying the water to the turbine, due to frictional losses. By careful design, this loss can be reduced to only a small percentage. A rough guide used for small systems of a few kW rating is to take the overall efficiency as approximately 50%. Thus, the theoretical power must be multiplied by 0.50 for a more realistic figure.

• Main Elements of a Hydro Power Scheme:

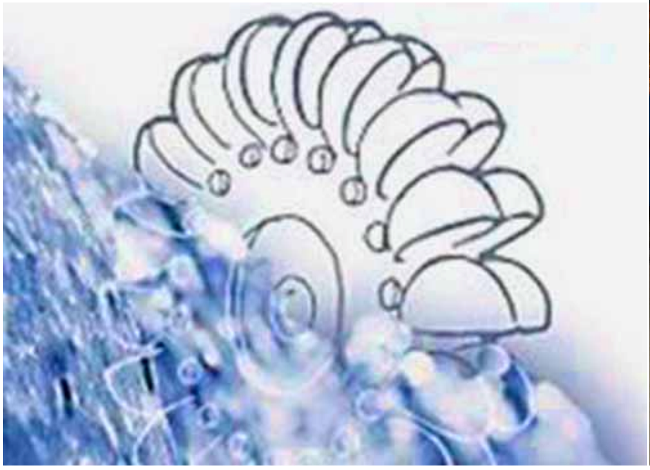
Main components of a small scale hydro power scheme can be summarized as follows:
• Water is taken from the river by diverting it through an **intake** at a **weir(small Dam).**
• In medium or high-head installations water may first be carried horizontally to the forebay tank by a small canal **(power canal).**
• Before descending to the turbine, the water passes through a settling tank or 'forebay' in which the water is slowed down sufficiently for suspended particles to settle out.
• **Forebay** is usually protected by a rack of metal bars (a trash rack) which filters out waterborne debris.
• A pressure pipe, or '**penstock**', conveys the water from the forebay to the turbine, which is enclosed in the **powerhouse** together with the generator and control equipment.
• After leaving the **turbine**, the water discharges down a **'tailrace' canal** back into the river.



(Fig.7) (An illustration of all principal components which might be included at a micro-hydropower site).

- ## Turbines

A turbine converts the energy in falling water into shaft power. There are various types of turbine which can be categorized in one of several ways. The choice of turbine will depend mainly on the pressure head available and the design flow for the proposed hydropower installation.



Conclusion

Micro hydro utilizes the energy of falling water to generate electricity. This is not to be confused with large scale hydro dam projects. A proper install has no negative effects on the local stream, simply diverting a portion of the available water and then returning that water back to the stream.

If your site has a source of running water, you simply must investigate its potential as a source of electricity. As experience has demonstrated that water power will produce between 10 and 100 times more power than solar or wind for the same capital investment.

Since water flows day and night, a micro hydro system requires far less battery storage than other technologies. Even if the stream is far away, it may still be viable. Distances of several kilometers can be covered by utilizing high voltage generators. Seasonal streams offer great performance when a hybrid water and solar system is designed.

When your power requirements are the highest, in the winter, the water is usually flowing the fastest. In the other hand solar modules are most efficient when there is the most sun in the summer.

Over the last few decades, there has been a growing realization in developing countries that micro-hydro schemes have an important role to play in the economic development of remote rural areas, especially mountainous ones. Micro-hydro schemes can provide power for industrial, agricultural and domestic uses through direct mechanical power or by the coupling of the turbine to a generator to produce electricity.