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Using Hydro-Energy: Back to Basics

Micro hydro systems complement solar PV power systems because in many areas, water flow, and thus available hydro power, is highest in the winter when solar energy is at a minimum. Micro hydro systems are very flexible and can be deployed in a number of different environments. They are dependent on how much water flow the source (creek, river, stream) has and the velocity of the flow of water. Energy can be stored in battery banks at sites that are far from a facility or used in addition to a system that is directly connected so that in times of high demand there is additional reserve energy available.

Hydro Energy

Hydro energy (energy associated with the flowing water) and its use for human needs are well known and used by the human from ancient times at individual, community, village and neighboring area levels. Applications of hydro energy to run water flour mills and for irrigation/drinking purposes was well explored by old civilizations all over the world. Long before hydro power began providing electricity; it was used to perform simple but labour-intensive tasks. There is no consensus among historians regarding when and where the earliest hydraulic technology emerged. It is clear, however, that water power was used extensively in the Roman Empire and eastern Mediterranean region by at least the first century BCE. At this time, water-powered technology took the form of water wheels-bladed wheels that sat on either a horizontal or vertical axis and transferred the kinetic energy of moving water into mechanical energy,

Water Floor Mill

Water Mill

most often to turn a millstone to grind grain into flour. Water power was also used to raise water for irrigation in Egypt and India by the first century BCE, while evidence suggests that water power was being used to operate forge bellows in China by the first century CE. The Romans, however, used water power on an extraordinary scale, driven in part by the necessity of grinding sufficient grain to feed its vast and growing population. Water mills provide another source of hydroelectric energy. Water mills, which were common until the Industrial Revolution, are large wheels usually located on the banks of moderately flowing rivers. Water mills generate energy that powers such diverse activities as grinding grain, cutting lumber, or creating hot fires to create steel.

Development Problems with Large / Medium/Small Hydro Power Plants

To harness energy from flowing water, the water must be controlled. A large reservoir is created, usually by damming a

Types of Hydropower Plants

Hydropower plant Category	Power Range	Use of Power Generated	No. of Homes Powered
Large	100 MW+	feeding into a large electricity grid	100,000+
Medium	10 MW - 100 MW	feeding into a large electricity grid	10,000 - 100,000
Small	1 MW - 10 MW	feeding into a large/small electricity grid	1,000 - 10,000
Mini	100 kW - 1 MW	either stand alone schemes or more often feeding into the grid	100 - 1,000
Micro	5 kW - 100 kW	usually providing power for a small community or rural industry in remote areas away from the grid	5 - 100
Pico	0 kW - 5 kW	usually providing power for a small community or rural industry in remote areas away from the grid	0 - 5

river to create an artificial lake, or reservoir. Water is channeled through tunnels in the dam. The energy of water flowing through the dam's tunnels causes turbines to turn. The turbines make generators move. Generators are machines that produce electricity. Engineers control the amount of water let through the dam. The process used to control this flow of water is called the intake system. When a lot of energy is needed, most of the tunnels to the turbines are open, and millions of gallons of water flow through them. When less energy is needed, engineers slow down the intake system by closing some of the tunnels. With all the requirements/needs and benefits / advantages of large / medium / small (called macro) hydro-electric power plants, planners for hydro-electric power generation are finding it difficult to come up with new hydro power plants due to opposition from the people with their concern about delocalization of masses, environmental concerns, breakdown fears etc. Author here is not to comment on the usefulness of large/medium/small categories of hydro energy power generation but would like to present some important limitations associated to these categories as:

- Reservoirs have multiple social and environmental effects (ecosystem damage, loss of land, siltation, methane production, displacement of people, failure risks, and water loss via evaporation).
- The huge dams required for hydroelectric energy projects create reservoirs that flood entire valleys. Homes, communities, and towns may be relocated as dam construction begins.
- As reservoirs require large areas, finding a suitable place for large-scale hydropower plants can be difficult
- Building a dam across a river floods the land that would otherwise be available for use, alters the landscape, affects the local community that would have lived and worked on the flooded land, alters the character of the river, and prevents the free movement of fish
- Permanent complete or partial blockage of a river for energy conversion is adversely affected by variations in flow
- Building large-scale hydro power plants can be polluting and damaging to surrounding ecosystems
- Changing the course of waterways can also have a detrimental effect on human communities, agriculture and ecosystems further downstream
- Hydro projects can also be unreliable during prolonged droughts and dry seasons when rivers dry up or reduce in volume
- The hydroelectric power potential from many river basins has not been developed on a major scale due to potential opposition from the tribal population
- Operating the power plant may also raise the temperature of the water in the reservoir. Plants and animals near the dam have to adjust to this change or migrate elsewhere.
- There are limits to the amount of hydroelectric energy a dam can provide. The most limiting factor is silt that builds up on the reservoirs bed. This silt is carried by the flowing river, but prevented from reaching its normal destination in a delta or river mouth by the dam. Hundreds of meters of silt build up on the bottom of the reservoir, reducing the amount of water in the facility. Less water means less powerful energy to flow through the systems turbines. Most dams must spend a considerable amount of money to avoid silt build-up, a process called siltation. Some power plants can only provide electricity for 20 or 30 years because of siltation.
- Hydropower plants can also cause low dissolved oxygen levels in the water, which is harmful to river habitats.

Development of Mini-Micro-Pico Hydro Power Plants (Back To Basics)

Scientists and engineers along with the planners are turning back to basics with new ideas of hydro energy utilization with its smaller capacity forms like mini, micro and pico categories not only to generate electricity but also to make use of hydro energy directly for purposes which either make use of electricity at individual or village level as in old days. It not important only to generate electricity from hydro power and then use electricity for human well being but hydropower can also be utilized directly (without converting it into electricity) though the applications may be limited and more labour intensive & less productive/efficient but this (utilization) of hydro power at local level will give lots of benefits. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks, particularly where net metering is offered. There are many of these

Fig.: Micro hydro power generation

installations around the world, particularly in developing nations as they can provide an economical source of energy without the purchase of fuel. Hydro power schemes can be ones set up to provide community-managed micro-hydro schemes for off-grid communities.

In Micro-hydro schemes usually supply a mini-grid and provide electricity to a whole community. In remote areas, micro-scale hydro schemes can bring electricity for the first time to whole communities. This provides lighting, TV and communications for homes, schools, clinics and community buildings. The electrical power generated can be enough to run machinery and refrigerators, thus supporting small businesses as well as homes.

Micro hydro systems complement solar PV power systems because in many areas, water flow, and thus available hydro power, is highest in the winter when solar energy is at a minimum. Micro hydro is frequently accomplished with a pelton wheel for high head, low flow water supply. The installation is often just a small dammed pool, at the top of a waterfall, with several hundred feet of pipe leading to small generator housing. Micro hydro systems are very flexible and can be deployed in a number of different environments. They are dependent on how much water flow the source (creek, river, stream) has and the velocity of the flow of water. Energy can be stored in battery banks at sites that are far from a facility or used in addition to a system that is directly connected so that in times of high demand there is additional reserve energy available. These systems can be designed to minimize community and environmental impact regularly caused by large dams or other mass hydroelectric generation sites.

Power produced from a small hydro station can be used for various purposes; some of the uses have been classified as follows:

	Mechanic	Electricity
Productive use	agro processing timber sawing textile fabrication cooling drying	mechanical uses with electricity as intermediate heating, lighting, fertilizer production
Consumptive use		domestic lighting, cooking, cooling, radio and television

As the above illustration shows power that is generated by micro power plants is a convenient source of electricity to fuel anything from workshop machines to domestic lighting as the power can also be supplied to villages via portable rechargeable batteries and thus there are no expensive connection costs. Batteries can as well be charged and used to provide the local community with power. For industrial use however, the turbine shaft can be used directly as mechanical power as opposed to converting it into electricity via generator or batteries. This is suitable for agro-processing activities such as milling, oil extraction and carpentry.

Advantages of Micro Hydro Plants

- Microhydro is considered a "run-of-river" system meaning that water diverted from the stream or river is redirected back into the same watercourse. Adding to the potential economic benefits of micro hydro is efficiency, reliability, and cost effectiveness.
- The simplicity and low relative cost of micro hydro systems open up new opportunities for some isolated communities in need of electricity. With only a small stream needed, remote areas can access lighting and communications for homes, medical clinics, schools, and other facilities.
- Microhydro can even run a certain level of machinery supporting small businesses.
- One seemingly unexpected use of such systems in some areas is to keep young community members from moving into more urban regions in order to spur economic growth.
- Also, as the possibility of financial

incentives for less carbon intensive processes grows, the future of microhydro systems may become more appealing.

- Micro-hydro installations can also provide multiple uses. For instance, micro-hydro projects in rural areas have incorporated agro-processing facilities such as rice mills- alongside standard electrification - into the project design.

Limitations of Micro Hydro Plants

- Many micro-hydro schemes are remote from the mains grid, and a local grid is constructed to distribute the electrical power. The output from the generator must match the demand for electric power on the local grid, otherwise the voltage and frequency can vary suddenly which can damage some electrical equipment. The demand for power in an off-grid system is often very variable, because people switch lights and machines on and off, so the supply from the micro-hydro system must be varied to keep close control. This can be done by varying the water flow, or by using an electronic load controller.
- To be economical, energy consumers need to be located near the hydropower scheme, thus limiting the application of small-scale hydropower to streamside communities
- The stream flow limits the power generation. Every micro hydropower plant has a maximum capacity, determined by the stream flow, which cannot be exceeded
- Seasonal variation in stream flow causes variation and disturbance in energy supply. Advanced planning is needed to ensure adequate energy generation throughout the year, especially in areas with a significant dry season
- Micro hydropower sites are often located in remote areas, so electricity distribution costs can be high, and there can be significant losses in the distribution grid

Micro Hydro Power Plant Development Barriers

There are various barriers that hinder the dissemination of micro hydro power (MHP) generation, some of them have been identified as:

Policy and regulatory framework:
In most cases there exist no sufficient policies and frameworks that govern MHP schemes, this is because the MHP is either not regulated at all or is combined with a broader framework made for rural electrification which may be unclear and in transparent. Such challenges cause the MHP project developers not to know which requirements apply and work in an unreliable grey area of regulation.

Financing:
Lack of sufficient funding to be used in development is a common challenge as most MHP rely on donor funding which in most cases is only available in funding a small portion of the hydro power potential. One of the ways that such a case can be addressed is if there can be an option of exploring other sources of funding especially from private venture capitalists and local banks.

Capacity to plan, build and operate MHP plants:
Lack of knowledge and awareness on MHP potential posses a great challenge for rural electrification, hydro power schemes still dominate as political decision makers still tend to go for them as a more "modern" approach. Combined with that there is minimal capacity to design, implement and revise the MHP supportive policies and regulations. And at the technical level, local capacity is often missing to plan, build and run MHP projects. The is also a problem in the lack of a ready supply of affordable turbine parts and the lack of domestic manufacturing capacity for hydro systems of all sizes also poses a barrier to a swift and cost-effective MHP project development.

Data on hydro resources:
There is usually a lack of interest in MHP deployment from the politicians and power utilities companied by the lack appropriate capacities and budgets, as well as unavailability of pubic data on MHP sites. Such a lack of sound basic data (e.g. on mid-to long-term hydrological, geographic, geologic data and figures on the current and future demand for electricity and social infrastructure, but especially on effects of seasonal and long-term river flow variations), poses a major barrier for private investors in MHP. This causes a bottleneck for investment in hydropower systems as there is an increase in climate variability accompanied with the destruction of rainfall catchment areas.

Misconceptions about Micro Hydro Power

Small streams do not provide enough force to generate power:
Energy output is dependent on two major factors: the stream flow (how much water runs through the system) and drop (or head), which is the vertical distance the water will fall through the water turbine.

A large water reservoir is required:
Most micro-scale hydro systems require very little or no reservoir in order to power the turbines. These systems are commonly known as 'run-of-river', meaning the water will run straight through the generator and back into the stream. This has a minimal environmental impact on the local ecosystem.

Hydro generators will damage the local ecosystem:
Careful design is required to ensure the system has a minimal impact on the local ecology. A small amount of energy compromise may result, but this will ensure that the project does not have an

effect on local fish stocks. The stream levels must be maintained at a certain level in order to sustain the life within. Since there is no loss of water in the generation process, these requirements can easily be met.

Micro hydro electricity is unreliable: Technology advances (such as maintenance-free water intake equipment and solid-state electrical equipment) ensure that these systems are often more reliable in remote areas. Often these systems are more dependable than the local power main.

The electricity generated is low quality: If the latest electronic control equipment, inverters and alternators are used, the resultant power supply has the potential to be of higher quality the main electrical power grid.

Cost: Micro power development can be cost-intensive to build and maintain. There are some fixed maintenance costs. These costs vary according to site location and material requirements.

Pico Hydro Power Generation

Intensive explorations of different alternatives and renewable energy resources are currently being conducted worldwide. Pico-hydro power is at the forefront of these options because it is considered as the most cost-effective renewable energy option to provide electricity for rural areas, and to enable energy to be derived from extremely low head and flow streams. Pico hydropower is the only form of small renewable energy production which works continuously without battery storage. Where applicable it is the most cost efficient solution to supply electrical energy. Pico turbines can provide power for small clusters or even single households.

In order to meet all the needs of the residents in electricity and hot water and since the property is located far from the main electricity grid and close to a stream that is running all year round, an off-grid pico hydro plant can be designed. In this way, the energy of the moving water mass is converted into electricity which is then stored in a small 24V battery bank. With the use of an inverter, the system has the ability to meet all the needs of the house in electricity such as lighting, general appliances such as TV, radio etc, washing machine, fridge and freezer. At the same time, and due to the continuous operation of the pico hydro plant, all the surplus energy that is not consumed instantaneously or stored in the batteries, is used for heating water for the kitchen and the bath.

Pico hydro power generation

From one end of the planet to the other, scientists and engineers are working on a variety of concepts - some real, others imagined - that will help make this very ancient power source an even more important modern one. Researchers believe to be able to generate electricity from toilet flushes, showers, faucets and gutters. Using a transducer that harnesses flowing water to generate small amounts of renewable energy, such devices might one day contribute to keeping the lights on.

In another development, a special three-bladed electric turbine sinked into the waterway which looks like a modern fan attached to a torpedo-shaped body, to generate electricity from the push and pull of the river's rushing currents. These turbines could dot the river, with each unit generating 35 kilowatts of electricity. If successful, the project could provide enough power to fuel hundreds of homes. Made of plastic and layered fiberglass, the tidal turbines are one of several technological innovations rocking the hydroelectric world.

Sources: The use of information retrieved to prepare this article from various references/sources of internet is highly acknowledged.