"Electricity is Half of Life!"

A Case for Using Micro-Hydroelectric Power (MHP) as a Primary Community Development Strategy in Qualifying Mountain Regions

By Brad Friesen
Clean Energy Consultant
brad@friesenenergy.com
Revised January, 2019

(Note: This article was originally written and distributed in 2001 to encourage the development of Afghanistan's substantial MHP potential, a process which was just getting started, and later mushroomed.)

INTRODUCTION

In the challenging and diverse field of village-level community development, a wide variety of approaches and programs can be utilized. Regardless of what the exact implementation strategy may be, interventions can be roughly sorted into three incremental stages:

1) Primary development, which focuses on water supply, food security and primary health care.

2) Secondary development, which includes sanitation and nutrition, crop and livestock diversification, fruit and vegetable promotion, health training and primary education.

3) Tertiary development, which expands into infrastructure development, income generation, micro-finance programs, commercial food production, reforestation, and such "luxuries" as electrification.

The selection, prioritization and implementation of specific programs, as individual projects or as components of a broader strategy, must carefully consider all of the following factors:

- The felt needs of the village;
- The needs of the village from a development perspective;
- An understanding of the unique set of social, political, environmental and technical parameters that characterize the focus area;
- The capacity of the village; and
- The capacity of the implementing agency.

However, in some regions, particular qualifying characteristics make it reasonable to consider "short-circuiting" the normal, somewhat plodding, progression of development by first implementing a more advanced project that, in addition to its usual outcomes, does a remarkable job in putting a community on a fast-track to pursuing development along more classic lines once it is completed, and dovetails smoothly with many other initiatives. For example, if a region is mountainous, has fast-flowing rivers, is out of reach of a national electrical grid, and is populated by people who are familiar with the benefits of electricity, have the potential to work together, and who are familiar with irrigation channels, masonry and carpentry - then an MHP program should be considered as a primary development strategy.

Though this may sound like putting the cart before the horse, consider that the most effective rural development programs are not the ones that just improve standard development indicator statistics like infant mortality rates and literacy. The best projects empower communities, and grow a vision for the future that they can pursue on their own. When such a project has the unusual advantage of being valued by every person in a community every night, there is a winning combination that fast-tracks positive change and unites people together. This is what MHP can do.

The many differences between alternative forms of clean energy, like solar, wind and hydropower, will not be reviewed here. However, it will be noted for this paper that MHP has a uniquely strong community building effect. An MHP installation requires all eligible workers to labor shoulder to shoulder for months to dig a channel, build various structures, and install heavy machinery. When it is started, an MHP plant has flowing water and rotating machinery that has an excitement of its own. When the power goes on, there is a feeling of corporate pride and accomplishment, a fraction of the elemental power of a river has been harnessed for the good of the community. Though there will be interruptions, the system can be maintained indefinitely, and it takes the village working in cooperation to do so. Whether day or night, with or without wind, and no batteries, the lights are on.

Examples of MHP as a Primary Development Strategy

Nuristan: In the 1980s, in the rugged and isolated Nuristan region of northeastern Afghanistan, accessible only by foot and pack animals at the time, one small but very united village at the high end of a valley struggled for years, with minimal outside help, to build one of the first MHP installations in the country. It was eventually completed with some expatriate help and funding, which included the purchase of small, custom-designed, motor-driven, corn and wheat threshers. They were made to be completely dismantled so that they could be transported to the village by man and animal, then reassembled on site. These were a success, and made threshing much easier than traditional methods. The project's completion encouraged the villagers to pursue their second priority, a spring capping project that would bring potable water from far up a mountainside to standpipes at their doorsteps.

Other larger villages in the valley, who previously admitted to being too divided to attempt an MHP project, were inspired by this village's tenacity, which was only too obvious every night when they could look up the valley and see their bright lights shining in the darkness. Not too many years later, those village also completed MHP installations.

This development sequence also illustrates how pilot projects are most effectively implemented in villages with the best leadership and social organization, not the ones with the most ideal geographical characteristics or the greatest need. United villages need the least outside motivation and stand the best chance of success, which will inspire others to follow their example.

AKRSP: This unusual strategy of starting development with MHP was also discovered to work in the remote, mountainous district of Chitral, Pakistan, by the Aga Khan Rural Support Program (AKRSP), in the 1990s. Once the first few experimental MHP projects had been successfully installed, the idea quickly caught on and numerous requests came in from other villages - no coaxing, incentives or presentations were needed to sell the idea. Although a substantial non-monetary investment was required from villages, there were so many requests that AKRSP had trouble keeping up. The Chitral District now has the highest concentration of MHP in the world.

Requests for MHP projects were often the first point of contact AKRSP was able to establish with villages, including those communities who initially wanted nothing to do with other proposals that AKRSP had brought forward. Once villages had been guided through the requisite social organization process and projects were completed, communities had developed the unity, confidence and vision necessary to pursue other projects AKRSP offered,

like road and bridge construction, veterinary services, micro-finance networks, schools, irrigation, horticulture, water supply and forestry.

IAM: The International Assistance Mission, an NGO based in Kabul, Afghanistan, initially started providing services to the country in health and education. In the 1990s they became involved in rural development with projects in poultry and horticulture, and they began the country's first MHP program. MHP projects quickly became the most popular first contact with the agency, after which villages requested help in other areas. Eventually IAM helped start several local workshops that could carry on the technology. This created numerous jobs, and exponentially increased the number of MHP plants that were able to be installed throughout the country.

ADA: The Afghan Development Association, an NGO working in southwestern Afghanistan, found that MHP projects helped to bring people together in otherwise hostile, multiethnic communities. The desire for electricity was so strong, and the need for cooperation so imperative, that they worked together to complete MHP projects. The installations also required continued collaboration between the disparate groups to keep them running. MHP can promote peace!

TERMINOLOGY

The technology: Micro-Hydropower / Micro-Hydro / MHP: A technology utilizing water-powered turbines of various designs to produce mechanical and/or electrical power in the range of 3-100 kWs. This range is generally accepted in the developing world, although the term "micro" is relative, and varies from country to country, and even agency to agency if a national standard has not been recognized. This term does not include traditional, water-powered flour mills. In China, micro-hydropower is anything under one megawatt!

An installation: MHP plant / Micro-Hydropower Project (MHPP) / Micro-Hydropower Unit (MHU): An individual MHP power plant installation, which may or may not produce electricity. In Nepal, many privately owned MHUs only use direct drive machinery, with possibly a small alternator for powerhouse lighting.

If electricity is produced: Micro-Hydroelectric Power Plant / Micro-Hydel / Hydel: An MHP plant that produces electricity. In Afghanistan and Pakistan, nearly every MHP plant is used to produce electricity (whether or not they also have directly driven machinery). The term "hydel" is used in Canada to refer to any size of hydroelectric plant, including those producing megawatts of power.

MHP PLANT DESCRIPTION

A typical MHP plant in the developing world uses a simple, temporary weir in a river to guide water into a channel that runs along a hillside to a point where there is a reasonably steep drop down to a lower elevation, which is usually the banks of the same river from where the water came from. The channel terminates in a a "trash rack" and "settling tank" where floating debris is filtered out, and the water is slowed down so silt and sand will settle. The settling tank has a "baffle wall" that keeps the settled material out of the next section, which is a tank called a "forebay", that pools the water and allows it to smoothly change direction, with minimal turbulence, as the water enters the mouth of a large pipe called a "penstock." The open top end of the penstock is attached near the bottom of the forebay, then goes down the hillside (anchored as needed) and into a powerhouse, where it is bolted to a turbine. The two most common types of MHP turbines are "crossflows" and "Peltons". Water flows down the penstock and into the turbine, where it strikes a series of blades on a shaft, which then spins.

The turbine shaft is attached to a generator shaft, usually with pulleys and V-belts, which then rotates and produces electricity. The generator is wired to a control panel, which is wired to overhead lines to distribution points in the village, where it is attached to smaller lines that lead to electrical boxes in individual homes.

MHP ENGINEERING

While MHP is not rocket science, it is still a challenge to design and install an efficient, easily operated, sustainable, safe, cost-effective project in a village setting. Elements of civil, mechanical, hydraulic and electrical engineering are involved, along with a range of construction trades. Unlike large hydroelectric power plants, which hire numerous specialists for design, construction and operation, an MHP engineer working with a small team must have a practical grasp of the full range of not only the technical issues involved, but the social ones as well. The engineer must be able to implement the entire project, from weir to household light switches, with unskilled labor in remote locations with minimal outside support, train local people to understand and successfully operate the completed plant, and facilitate the village in forming the necessary social organization and management structures needed to keep the project sustainable. This can all be intimidating, but the results are worth the effort.

ELECTRIFICATION BENEFITS

Light: In many villages where MHP plants have been constructed in South Asia, the primary motivation to have electricity is simply to have good light. According to one bearded elder in Afghanistan who had recently been able to turn on two fluorescent light bulbs in his mud home as a result of one of IAM's MHP projects in his village, ***"Electricity is half of life!"***, which inspired the title of this report. When asked what the other half was, he responded by saying, "Health, education, good water, things like that."

It is difficult to quantify the subliminal advantages of good illumination that this elder noticed, but bright, clean light does make a dramatic, though silent, improvement in lifestyle all by itself. But electricity can do much more, including positive effects in every other part of life that the elder mentioned. Following is a review of some of these benefits, many of them overlapping, in the areas of health, environment, education, income generation, benefits to women, community services, District Centers, birth-control, agriculture, micro-finance and communications. In the West, many of these benefits are well known, and taken for granted, but they are reviewed here in a development context.

Health: Good light is an integral part of good health. Many village homes cook over three stones in the middle of a home, or they use a poorly ventilated fireplace or fire pit, so that they can have light as well as heat when cooking and heating their homes. This results in a considerable amount of smoke inside the home, which causes eye and lung irritation and disease. Electric light allows cooking with the use of efficient, closed, metal stoves with pipes that get smoke out of the room, and use less firewood.

Health is also improved because dirt can be seen with good light, and cleaned up. Villagers in one area frequently mentioned that they appreciated good light because it helped them to spot, and eliminate, centipedes, scorpions and spiders in their homes before they caused harm. Good health not only improves longevity and productivity, but it also means less money is spent on medications, which is a major financial drain on many villagers, as well as the expense of travel to clinics.

Medical facilities can provide better care with electricity. Operating rooms can have sterilization equipment, good lighting, and even air-conditioning to provide a clean and controlled environment. Refrigeration for medicines and specimens becomes possible, and cold chains for vaccines. Centrifuges, microscopes, slit lamps, monitors, computers and other medical equipment can also be operated.

A significant health benefit is clean water. When there is electricity to pump and transport clean water so that it becomes easier to access for drinking and washing, health improves.

Environment: Enclosed stoves use less wood, and use it more efficiently, than open fires, which saves on the consumption of fuel wood. Electricity also saves on the purchase and consumption of diesel for lanterns, oil for lamps, candles and batteries (which are poorly disposed of). In some areas, villagers burn special pieces of conifer wood that have a high quantity of pitch, using them like small torches when moving around in the village at night. One villager reported that they used to be able to get this wood from trees very near their homes, but they now had to bring it from many hours away. An MHP plant in their village has now eliminated that need by providing street lights, which also improves security.

Although most village MHP plants do not produce enough power for the regular use of heat generating appliances like irons, water immersion heaters and hot plates (for cooking), with proper power management (discussed below) this can also be done, which makes a very significant reduction in the use of fuel wood.

Education: Children frequently have to walk around two hours each way to a centrally located school, and have to work in the fields when they return home. This makes finding time to study during daylight hours difficult, and firelight is not conducive to reading. Children can study longer, and better, with electric lighting. In the schools themselves, electricity allows indoor lighting and the use of computers, lab equipment, projection equipment, and other devices, which revolutionizes the educational process.

Income Generation: Handicrafts are an important source of income for some village women, but they seldom have time to work on them during daylight hours. Such things as intricate embroidery and bead work is much easier to do at night if there is good lighting. In one region, wool cloth production was an important industry, but much of the work had to be done indoors. Smoke from open fires made it difficult to keep the product clean, and quality could not be easily monitored. MHP plants installed in those villages not only provided better light to see what was going on, but also made it possible to use various powered machinery, like wool carders, spinners and sewing machines. With these changes men became involved along with women in the manufacturing process, which led to better gender labor equality, and greater production and income.

Electricity makes it possible to use a wide variety of power tools, industrial appliances and larger machinery, from electric bakeries to welders and wood-working equipment. Saw mills utilize wood more efficiently than the traditional adze when making a board. When dimensional lumber is available, it is much easier to build cupboards, shelves, trunks, doors, windows and other wood products which improve lifestyles and generate income. However, saw mills can do more damage than good by increasing wood consumption, so it is best to encourage communities and sawmill owners to do reforestation projects, and to understand principles of conservation.

One village was located at the end of a high valley, near the tree line, with no known prospects for significant income generation, until a deposit of high grade soap stone was discovered in the area. An entrepreneur developed the site, employing 10 men to mine the stone and hiring local jeeps to transport it to a district center for shipping down-country. Later, an aging MHP plant in the village was rehabilitated, and electronic controls were added, making it possible to grind and mix the soapstone with machinery before shipment. The added value, using virtually free electricity, significantly increased profits.

At the minimum, every MHP plant generates at least two jobs, which is the number of operators normally employed.

Although the electrification benefits mentioned here are extensive and exciting, the majority of rural communities need intensive encouragement to go beyond using electricity for only illumination and household appliances. Local entrepreneurs are key, and must be

supported, but others might have opportunities at their finger-tips, and just need a little coaching and encouraging.

Benefits to Women: Along with cleaner homes, healthier children, and improved income generation, electricity also benefits women, and home life by allowing more flexibility in the timing of household chores. With good lighting, such activities as sweeping, cleaning rice, bathing children, sorting grain and cooking are made much easier, and can be done as easily at night as in the day. Labor saving devices, such as butter churns and simple clothes washing machines can make the lives of women easier, along with such things as irons, water immersion heaters, and hot-plates, as discussed above, if there is enough power.

During hot summers, even a small fan is a huge bonus. Indoor work is more bearable, homes are ventilated, there is less problem with flying insects, and sleep is improved. The numerous benefits of good sleep are usually not appreciated until one doesn't get one.

These benefits to women are so important, that often women are the prime movers to get their village electrified. One group of men came into an MHP project office rather sheepishly, and told the engineers that their women had beat them because they had not installed an MHP plant. "Can you help us?"

Community Services: Most MHP plants do not generate enough power for every family in a village to simultaneously use appliances that use a large amount of electricity, and even if they did, few can afford them. However, with proper power management and community cooperation, facilities such as community washing centers can be built. A washing center is a place where a significant amount of power can be used during the daytime, when lighting loads are reduced. The power is used for electric boilers, washing machines and irons that are all housed in a community center that is shared by everyone for washing clothes and themselves. Not only does this make life easier, particularly for women in cold climates, but it also provides a social center for women, which is particularly valuable in societies that don't allow women much freedom. Water heating can also be done at other community gathering places, like mosques, where wood is usually consumed to provide hot water, if it is provided at all.

District Centers: Electricity is crucial in the development of District Centers. These Centers are where many of the benefits listed in this review are based. District Centers have government offices, health facilities, educational institutions, regional markets, transportation centers, communications installations and agency offices. Many of these institutions need to operate office equipment to run well, and they need to be able to operate at night. Benefits from the development of District Centers extends to numerous villages which depend on these Centers for governance, goods, and services, particularly as many of these Centers are located at the confluence of several valleys or roadways. Electricity facilitates the growth and strengthening of these national "building blocks".

Birth Control: Though at the time of this writing no firm data had been collected, there is strong anecdotal evidence that good lighting reduces population growth for two reasons. One reason, attested to by more than one group of grinning men, is that with electricity available late into the night, and with entertainment on the TV or radio, couples spend less time in bed, and corners where the beds are located are not as dark as they used to be! A second reason is that electricity improves lifestyles, and where the quality of life improves, numerous studies show that there is a reduction in population growth.

Agriculture: Electricity can increase agricultural productivity by powering irrigation pumps which are seldom economical if powered by diesel generators. Though the water that can be pumped by an average MHP plant is not enough for large scale cereal crop irrigation, it can be used to irrigate household vegetable plots and tree plantations.

A drought in one valley had dried up the small side streams which the people used to irrigate their usual cereal crops, and their orchards. The main river was too far below their

fields to make it possible to hand carry water up the steep mountainside for irrigation. They had resigned themselves to not being able to plant their crops, but they were desperate to be able to at least save their orchards. An MHP plant was constructed that was able to pump enough water from the main river to save their trees.

Agricultural processing equipment can be run off of electricity that increases the value of the goods before they leave the village, and for village use. It is worth making a special note regarding flour milling. In many villages, the best site for an MHP plant is already taken by traditional water-powered flour mills. This can lead to conflicts in communities over water and site use, as well as flour milling business. However, a 'modern' high speed mill can grind grain three times faster than a traditional mill, and with transmission lines and a motor, the mill can be placed conveniently in the middle of a village, reducing transportation difficulties and waiting times. However, in some areas, villagers prefer the finer quality and taste of 'slow stone ground' flour, which is only possible in traditional mills. In addition, some village women value the social interaction and chance to get out of the house offered by an afternoon 'trip to the mill'. All that being said, if a fast, new mill is a possibility in a village, the community should be guided through a review of whether or not it is a good idea for them.

Refrigeration also becomes possible with electricity, on a family, business or communal level. This helps to diversify diet throughout the year, which improves health and vitality. Stored foods can be consumed in off-seasons, or sold at higher prices. If an animal is slaughtered, it does not have to be all consumed soon after it is butchered, as the meat can be preserved for later, or packed in ice and shipped to a more profitable market.

Micro-Finance: Micro-finance systems can be set up using tariffs collected for the consumption of electricity, with rates decided by the village. Tariffs can be set by household, or per bulb or appliance. The tariff is usually less than half of what an average household would have been spending on diesel, kerosene, candles and batteries for intermittent and poor lighting. The most equitable way to determine tariffs is to install inexpensive kilowatt-hour meters, then everyone pays for exactly how much electricity they consume.

Most villages collect just enough money to pay their operators, do minimal maintenance, and make necessary repairs. However, if villages collect a little more, tariffs provide an equitable 'tax' system, an invaluable way to fairly pool finances, which are under the village's complete control, not some money lender or outside bank. Such funds can reap enormous benefits by financing community initiated projects, or providing loans for agricultural activities, shops, handicraft supplies purchased in bulk by co-ops, home construction, medicine, or emergencies. In one area of very organized villages, communities had savings of $5,000 to $10,000 dollars, which were collecting interest in banks. Some of them used these funds for hiring teachers for schools, running clinics, and even paying laborers to repair irrigation channels and roads. This latter use of funds has a special significance, as previously the communities had relied on volunteer labor, which the wealthy rarely participated in, though they benefited from it. Now that laborers were being paid, life became fairer.

Corporately collected and managed finances are a huge jump forward, and an MHP plant is the best way to get these financial systems started.

Communication and Entertainment: Communication and entertainment are crucial benefits electricity can provide, whether it's to charge mobile phones, power telecom towers, run computers, or turn on radios, TVs, and satellite dishes. Electricity can help provide news and information from around the world to connect the remotest corners of our planet - for better or for worse. Be it for families and friends to keep in touch, medical emergencies, sports news, battlefield movements, educational shows, stock quotes, movies, smut, research, weather, politics, revolutions or checking the price of mutton from the high pastures to see if it's time to take a flock to market to sell, communication is an integral part of our interconnected world.

OTHER MHP PROGRAM COMPONENTS

This report focuses on the benefits of an MHP program, not how to do it. In addition to technical aspects that have been briefly mentioned, other MHP program components that will not be discussed in detail here include the following:

Social organization: Village social organization is a critical topic for a sustainable MHP project. Topics include how to initiate a dialogue with a village; checks and balances to put into place when a village opens a bank account; what to do when a household refuses to pay their bill; and how to identify and include the poorest of the poor in a community. Social organization also includes setting up ledgers for payments, determining the amount of money that needs to be set aside for repairs, and other aspects mentioned earlier in regards to such things as micro-financing so that corporately held money can be put to good use.

Capacity building: An MHP program does more than generate electricity and all the other benefits listed above. It also makes an important contribution to building capacity in a village, region and country. In cooperation with all local experts and by incorporating local techniques, capacity building happens when plant managers are trained in management and finances; operators in mechanics; villagers in electrical safety; engineers in surveying and calculations; site supervisors in construction techniques; and government employees in their areas of interest. Capacity is also built by training manufacturers to produce turbines, gates, trash racks, penstocks and other components; and by working with electrical contractors to design, fabricate, wire and install electrical panels and controls. Capacity is also built when importers are worked with to bring in new products required for the industry, from quality suppliers.

Networking: Many of the items listed under 'Capacity building' also involve networking. This happens between villages, government departments, funding entities, implementing agencies, companies, contractors, manufacturers, importers and international suppliers. Universities can also be involved, with opportunities for students to work on practical designs, problems, and field applications. For example, mechanical engineering seniors from one country's top technical university consulted an MHP expert for their final design project. Networking can take place at all levels and in all places, from forebays to shops, offices, lecture halls, symposiums and forums. It is fostering social organization on a grand scale.

Power Management: On quite another level, an important management issue is the use of power. Unlike solar and wind power sources, the energy production of an MHP plant is normally very stable. What fluctuates is the load requirements. If there is excess power, like very late at night, electronic controls allow the power to be dumped or the water flow restricted. There are a number of ways to put this excess power to use. Power management issues come up when the load exceeds the supply. A general observation is that when a new MHP plant is installed, there is often enough electricity for a maximum of 6 months. After that, the demand for power exceeds the supply, and policies need to put into place to manage, ration, share or alternate power usage. If this is not done, conflict over the use of electricity can become divisive, an outcome opposite of unity and the original intent of the project.

SUMMARY

Village electrical generation, through a technology like MHP, can speed up the often slow pace of rural development. Benefits start with bright and convenient illumination, but continue on with resulting improvements in health care, the environment, education, income generation opportunities, safety and quality of life at home, flexibility in scheduling activities, growth of community services and district centers, indirect birth control, agricultural processing, micro-finance possibilities, communications, entertainment options, social organization and capacity

building at multiple levels – from operator training to expanded markets. New things and good change take time and effort to develop, but the rewards are great.

CONCLUSION

Micro-hydropower
Utilizes a Local, Renewable Energy Resource,
Unifies and Empowers Communities,
Produces Immediate, Concrete Results,
Dramatically Improves Lifestyles,
Daily Benefits Everyone in a Community,
Generates Equitable Community Savings,
Inspires and Integrates with further Development Initiatives,
Markets Itself, and
Grows a Vision for the Future...

< < < > > >