Canada-Nepal Export Product: The Benefits of Using Renewable Micro Hydro in Nepal

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Part 1: Product information

Product Introduction

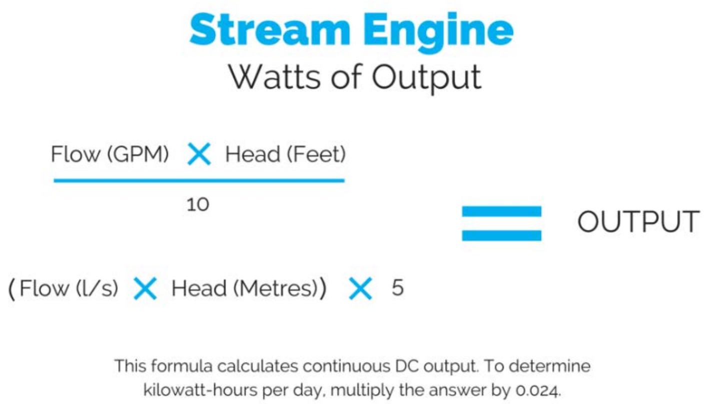
Micro hydro functions by harnessing the potential energy of natural water resources and converting it into useable electricity. It does this by using flowing water from streams, rivers, and lakes to spin a small turbine to produce power and charge batteries. These systems have been implemented and proven around the world as a clean and reliable method of producing electricity for isolated and off-grid homes and communities. Energy Systems & Design is a Canadian company located in Sussex, New Brunswick that produces a variety of micro hydro turbines. This report will investigate and analyze the benefits of using micro hydro systems in agriculture, and the potential exportation of this product to Nepal.

How it works

A micro hydro installation functions based on different variables. Different sizes of installation will produce different amounts of power, and different types of water sources require different types of turbines. Water sources are characterized by two different criteria; the amount of flow in litres/second, and the 'head' which is the local height from the top of the water source to the turbine (Cunningham & Woofenden, 2007). There also exist two different types of turbines that are suitable depending on these criteria. The first is the impulse turbine, which uses pressure created by gravity to spin a turbine in open air (Parish, 2002). The most common impulse turbine is the Pelton wheel, a high head, low flow variant where water enters through a protective grate to screen out debris and travels down a pipeline to be ejected as a small stream from a nozzle and spin the turbine wheel (Cobb, Sharp, 2011). A Pelton wheel uses split bucket blades that split a jet of water in half and direct it backwards almost 180 degrees to propel the turbine forwards, and normally uses up to 4 water jet nozzles (Parish, 2002). Another variation of micro hydro is the reaction turbine which uses the flow of water to turn a turbine that is completely immersed in water; this method is usually implemented in high flow and low head sites (Parish, 2002). A reaction turbine can use a propeller system spun directly by the movement of a river by channeling large amounts of liquid into the turbine (Parish, 2002). For a propeller turbine to properly function, the water must be swirling when coming into contact with the propeller to maximize power output, this is obtained by the addition of guide vanes upstream of the turbine (Parish, 2002).

A generator produces electricity from the spinning force of the turbine, and the power is transferred to a battery bank housed separately from the turbine. Power emitted by the generators is measured in Watts, and is dependant on the frequency at which the turbine is spinning. According to Paul Cunningham of Energy Systems & Design, the typical Canadian household can use approximately 300W of electricity at a given time; this includes lights, refrigerator, clothes washer, and television (Cunningham, Personal Communication, 2016). A small to medium sized micro hydro installation working at optimal speeds is capable of producing 200 W to 2 KW of electricity (Energy Systems & Design, 2016). Since a micro hydro system produces power at an almost constant rate, one must adjust the size of their battery bank to suit their power needs. For example, if a household normally uses 200-250 W of electricity, that has a micro hydro installation that produces 300W, may consider installing a larger battery bank to ensure enough power is reserved in case of a power spike over 300 W (Cunningham, Personal Communication, 2016). Alternatively, for a household that has the same energy needs, but with an installation producing 1 KW, a smaller battery bank is required as a spike will not likely exceed output (Cunningham, Personal Communication, 2016).

When considering a potential site, one of the deciding factors is the potential electrical output. This can be calculated using the formula depicted in figure 1, where the flow, calculated using litres/second, is multiplied by the head in metres, and multiplied by 5 to give the watts of power produced. To determine the head, one may need to survey a site or research the information form geological survey maps (Cunningham, Personal Communication, 2016). To determine the flow, one may need to conduct a bucket test in which a bucket is allowed to fill for a number of seconds, then the volume of liquid in the bucket is divided by the number of seconds to determine the rate of flow in litres/second (Cunningham, Personal Communication, 2016).



Source: Energy Systems & Design, 2016. Retrieved from: http://www.microhydropower.com/wp-content/uploads/2011/06/Stream-Engine-Watts-1024x576.png

Figure 1 illustrates the equation for output in watts of a micro hydro system in imperial and metric units.

Components and Planning Required

A micro hydro system requires planning and many components other than the turbine itself to function. This makes it extremely expensive to assemble a quality and efficient system. When a suitable site for a micro hydro installation is located, one must then begin planning the layout of the components and arrange shelter. For the installation of an impulse turbine, a suitable water source, usually an elevated lake or pool, with high head is needed. Next a penstock, or pipeline, for transporting water is required (Cunningham, Woofenden, 2007). The type of penstock used depends on the climate; the most common penstock is PVC pipe laid at a continuous slope along the ground. If there is a chance of the penstock freezing it could be buried to reduce the risk, and if the climate is very cold, a metal penstock can be buried (Cunningham, Personal Communication, 2016). An impulse turbine can also be housed to shelter it from the environment and reduce the chance of damage. A reaction turbine requires a large flow source, and is submersed in the water itself, therefore no penstock or shelter is needed (Parish, 2002). Both reaction and impulse turbines require a battery bank to store the power generated, and a dump load if the installation is off the national power grid (Cunningham et al., 2007). A dump load is an electrical heater that consumes any excess electricity produced to keep the system from damaging itself, typically a water or air heater (Cunningham et al., 2007). Having a dump load should not be viewed as a disadvantage as it still provides a very useful service such as heating a room, or providing hot water for showers.

Description of product

Energy Systems and Design is a Canadian company based in Sussex, New Brunswick, that specialises in micro hydro turbines and installations. The Company is owned and operated by Paul Cunningham. To contact Energy Systems & Design, visit the website at www.microhydropower.com, e-mail sales@microhydro.com or call 1-506-433-3151 (Energy systems & Design, 2016). Energy Systems & Design produce three unique micro hydro turbines designed and built in Sussex, NB that are specially adapted to different terrains and water sources, as displayed in Table 1. The first is the LH1000 or Low Head 1000 which uses a low head and very high flow of water (Energy Systems & Design, 2016). The LH1000 is a propeller reaction turbine and is designed to function best in rivers instead of high mountain streams, as a water source is diverted so that some or all of the water flow is directed through the turbine. It is capable of producing up to 1.5 Kw of electricity (Energy systems & Design, 2016). The LH1000 would be best suited for use in the Terai region where the terrain is flatter and suitable for larger rivers (Chapagain, 2016). The second is the Stream engine and X-Stream Engine, both Pelton wheel impulse turbines designed to function with a high head and low flow (Energy Systems & Design, 2016). These turbines are capable of producing up to 1 Kw and 2 Kw respectively, and outfitted with up to 4 nozzles for maximum power output (Energy Systems & Design, 2016). These turbines would be best suited to the hills and mountain regions of Nepal to service small agricultural communities. The third is the Watter Buddy, a small impulse turbine also designed to function with a high head and low flow (Energy Systems & Design, 2016). The small turbine can generate up to 200 W of electricity, and can also be outfitted with up to 4 nozzles for higher output (Energy Systems & Design, 2016). This turbine would be best suited to the hills and mountain regions, but the small amount of power produced would only be enough for a few households.

TURBINE	POWER OUTPUT	OPTIMAL HEAD AND WATER FLOW	COST ($CAD)
LH1000	Up to 1.5 kW	-- 0.6m-3.0m of head -- 500-1000 gallons of water/minute.	$2975
STREAM ENGINE	Up to 1 kW	-- 3m-100m of head -- water flow dependent on number of nozzles	$1995-$2445
X-STREAM ENGINE	Up to 2 kW	-- 3m-100m of head -- water flow dependent number of nozzles	$2295-$2745
WATTER BUDDY	Up to 200 W	-- 3m-100m of head -- water flow dependent number of nozzles	$695

Source material retrieved from: http://www.microhydropower.com/our-products/

Table 1 depicts the differences in power output, water source requirements, and price of four turbines produced by Energy Systems & Design.

Benefits to Canada

Micro hydro installations are not very common in Canada as the national electrical grid extends into most rural areas. This also means that anyone that chooses to establish a micro hydro system can choose to connect it to the national grid, and sell their electricity to the provincial government (Cunningham, Personal Communication, 2016). This also means that a dump load is not needed as any power produced is transferred to the grid. This system could also be used in Nepal where electricity is already present, to make a profit off of a micro hydro system.

Exporting this product to Nepal would also benefit Canada in several ways. First, Energy Systems & Design would benefit from any increase of product sales, which it can then use to possibly expand and put more money into the local economy. Sales of this product to Nepal would also advertise Canadian micro hydro in Nepal as a contender with any other micro hydro companies trying to sell their products there. This would therefore place Canadian micro hydro in a leading role in harnessing an underused energy source in Nepal and possibly make it the most popular when deciding where to buy a micro hydro turbine from.

Part 2: Exporting to Nepal

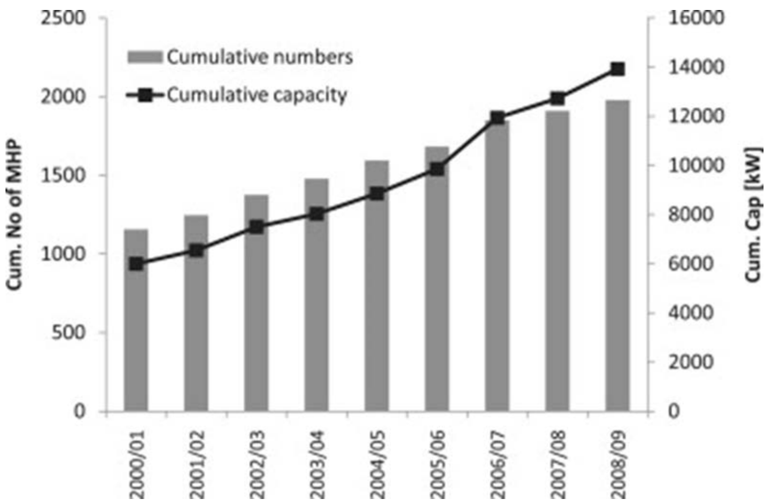
Introduction to Nepal

Nepal is a small landlocked country encapsulated by China and India (Chapagain, 2016). Nepal is home approximately 29 million people as of 2016 with about 1.2 million people living in its capital and largest city Kathmandu. Nepal can be divided into three main physiographic regions: the first is the Terai region, located in the south, it is the flattest and warmest region and consists of mostly intensive agriculture (Chapagain, 2016). The hills region, located in central Nepal, uses mostly terraced farming, and extensive animal agriculture (Chapagain, 2016). And the mountains region, located in northern Nepal is home to very little plant agriculture and mainly nomadic animal farming (Chapagain, 2016). More than 70% of Nepali people are employed in the agriculture sector, which accounts for 38% of Nepal's GDP.

Nepal has a bounty of natural freshwater resources, from small streams and lakes of melt water in the mountains and hills, to large rivers in the Terai. This provides the Nepalese people with many benefits and services, the best of these being electricity generated by largescale dams. Nepal makes good use of harnessing some of this potential energy as 92.5% of all electricity in the country comes from hydroelectric generators (CIA World Factbook, 2016). Still, 6 million people in Nepal are without electricity (CIA World Factbook, 2016), mostly in rural communities in isolated areas. A micro hydro installation would benefit these individuals by providing them with electricity from a clean and renewable resource.

Micro Hydro in Nepal

Micro-hydro schemes are not new to Nepal as the government has initiated many renewable energy programs, particularly micro hydro installations to expand rural electrification coverage (Gurung, Ghimeray, & Hassan , 2011), helpful to both agricultural use and expansion (Biggs, Duncan, Aitkinson, & Dash, 2013). The government of Nepal even offers subsidies for those who install a micro-hydroelectric plant. One can receive up to 12,000 Nepalese Rupees, or $146 CAD, for installing a system under 5Kw, and up to 15,000 Rupees, $183 CAD, for a micro hydro system between 5-500Kw (Gurung et al., 2011), and one does not need a license on any micro-hydro installation that produces under 1000Kw (Biggs et al., 2013). The Agriculture Development Bank of Nepal also provides loans to households seeking to install a micro hydro system in order to promote micro hydro (Gurung et al., 2011). Therefore, a business owner, farmer, or even a community could operate a micro-hydro plant, only having to pay the cost of the turbine itself (Gurung et al., 2011) and any additional components required. This means that Nepal, which only uses about 1.5% of its hydro-electric potential and has more than 6000 perennial rivers, is a serious potential market for Energy Systems & Design's products (Gurung et al., 2011). Micro hydro first took off in Nepal in the 1980s when the government first introduces subsidies, and the number of micro hydro installations has increased since (Gurung et al., 2011). Pictured in figure 2 below is the number of micro hydro installations in Nepal, notice that the total number of installations rises each consecutive year, and the total number has increased by more than 50% from 2000 to 2009 (Gurung et al., 2011).



Source: (Gurung et al., 2011)

Figure 2 depicts the number of micro hydro installations in Nepal from 2000 to 2009 compared to the cumulative capacity of these systems.

Needs and Benefits of the Importing Nation

Nepal, like Canada has immense fresh water recourses, generally streams and rivers, that represent wasted potential energy that could be harnessed and used for power production. It is estimated that all flowing water in Nepal could produce up to 83 Gigawatts of power, of which 43Gw is considered technically feasible (Gurung et al., 2011). Yet still, approximately 6 million people in Nepal, mostly in rural and isolated agricultural communities are completely without electricity (CIA World Factbook, 2016). A micro Hydro installation could provide power for these remote communities. This can aid in any number of daily activities including improving human and animal health services by powering medical equipment; aiding in agricultural and building projects by charging power tools; and helping to extend the shelf life of foods and vaccines by powering a refrigerator. Micro hydro also provides a sense of responsibility for the environment as it is powered by a renewable resource, and produces no waste products. The only drawback to micro hydro is that it can be very expensive to install, and will not function safely with out all of the required components. The average Nepali makes the equivalent of $881 CAD a year (Chapagain, 2016), which is not enough to feasibly buy components for a micro hydro system. However, it would be feasible for an entire community to contribute to the building of a micro hydro system, each purchasing a small component, then sharing the electricity. In a study conducted in 2009 monitoring a micro hydro installation installed in 1996 in Nepal and producing 27Kw of electricity, the total cost was US $48,390 where 20% of the cost was covered by The Agriculture Development Bank of Nepal (Gurung et al., 2011). This installation provides a good idea of the cost of a large micro hydro installation, likely using several turbines and a large battery bank, and it can be inferred that the total cost of a small system producing 1-2Kw would lower.

The use of micro hydro installations would also benefit the Nepali economy by aiding poorer citizens like farmers that must function without electrical aid to use electrical equipment like power tools and refrigerators to help increase their yield, and generate more income. The export of this product from Canada would also strengthen Canada-Nepal trade relations as Nepali people looking to install a micro hydro system would find a Canadian product.

Transportation Logistics

As this product is very specialized and would likely only sell a small number of units, it would be shipped a single unit at a time. This is possible by using several courier services; Canada post can ship directly from Energy Systems & Design in Sussex, NB, to Kathmandu. To ship the Watter Buddy it would cost approximately $174 CAD, and to ship the Stream Engine, X-Stream Engine, and LH1000 it would cost approximately $190 CAD. Transportation in Nepal would be more difficult as the main target of this product is remote agricultural communities. If possible, the package could be transported to a village or city nearest to the desired location and await pickup by the customer.

Product Competition

Micro Hydro represents a very small market with producers based mainly in western countries where demand is highest. Energy Systems & Design often sells turbines in the United States of America and around the world as there is not much global competition (Cunningham, Personal communication, 2016). Searching retail websites such as Amazon and Alibaba give few results, and no produces, whereas researching micro hydro provides results for small companies based in Canada and the United States of America where Energy Systems & Design is the first result and the most comprehensive.

Conclusion

With a lack of sufficient electrical and grid infrastructure (Gurung et al., 2011), and 6 million people that lack and could benefit from increased and reliable power (CIA World Factbook, 2016), Nepal would be a good potential market for the products of Energy Systems & Design. The marketing of these turbines will serve to increase the demand for micro hydro in a country that will likely experience high growth in electrical demand until 2029 (Gurung et al., 2011), providing revenue and growth to both a unique Canadian company, and electricity to small remote communities lacking a basic human amenity. It can also help to increase awareness of quality Canadian exports in international market, and serve to strengthen Canada- Nepal trade ties. Most importantly, it will serve to promote safe, clean, and renewable energy sources in a developing county, while also demonstration the potential to do so around the world by harnessing an almost endless and replenishing natural resource.

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