5. Micro-Hydro

Sector: ENERGY

Sub-Sector/Technology Option: Micro-hydro power

Technology Application: Micro Hydropower Run-of-the-River Facility for Douglas D' Silva Forest Station and Tourist Centre, Mountain Pine Ridge, Belize

Introduction

Micro-hydro power is the small-scale harnessing of energy from falling water, such as steep mountain streams or small rivers. Using this renewable, indigenous, non-polluting resource, micro-hydro plants can generate power for homes, hospitals, schools, workshops, environmentally friendly tourist destinations, forest station facility and small farming communities.

Small-scale hydro schemes can generate up to 500 kilowatts of power. The micro-hydro power station, which converts the energy of flowing water into electricity, provides poor communities in many rural areas around the world with an affordable, easy to maintain and long-term solution to their energy needs (Practical Action, 2016).

Micro-hydro: How it Works

"Run-of-the-river" systems do not require a dam or storage facility to be constructed. Instead water is diverted from the stream or river, channelled into a valley and drop through a turbine via a pipeline called a penstock (See Figure 1).

The turbine in the power house drives a generator that provides the electricity to the local community. By not requiring an expensive dam for water storage, run-of-the-river systems are a low-cost way to produce power. They also avoid the damaging environmental and social effects that larger hydroelectric schemes cause, including a risk of flooding. Water from the river is channelled through a settling basin, which helps to remove sediment that could harm the turbine. The water then flows into the Forebay Tank where it is directed downhill through the penstock. When the water reaches the bottom, it drives a specially designed turbine to produce the electricity.

Micro-hydro power systems are designed to operate for a minimum of 20 years. It is a low-cost way to produce electricity by barrowing the water from the river and returning it safely back farther downstream. Micro-hydro power is entirely renewable energy and is an alternative climate change mitigation technology that can transform the life of rural communities, who are generally the first and worst that are being impacted by climate extremes connected with climate change.

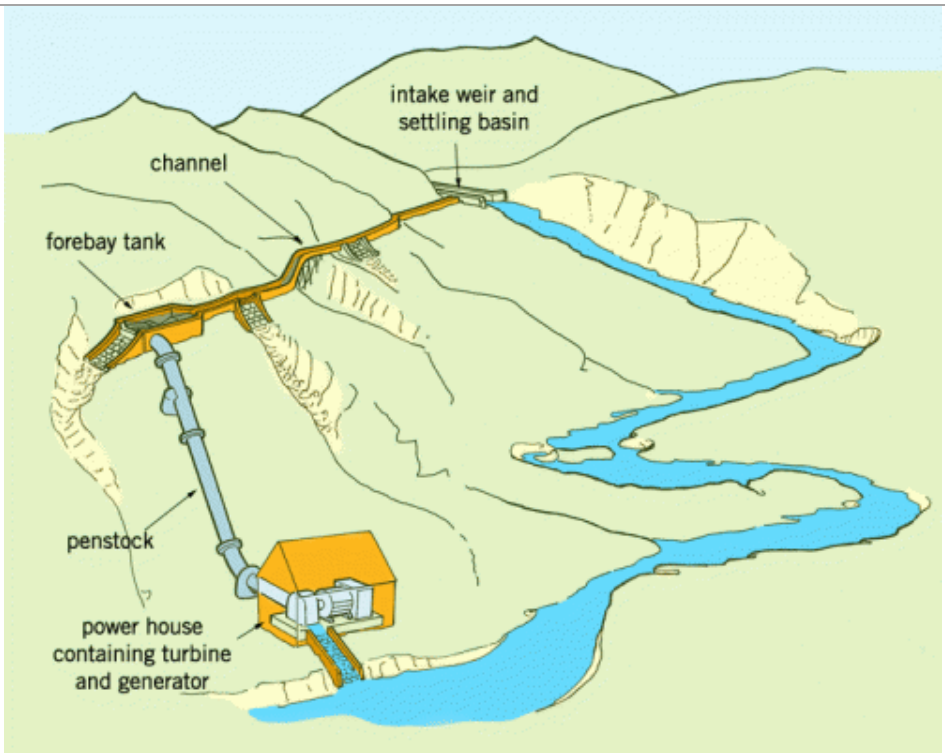

Figure 1. Schematic of a micro hydroelectric power system.

(Source: Practical Action, 2016)

What's the environmental impact?

In contrast to traditional power stations that use fossil fuels, micro-hydro power generators have practically little no effect on the environment. Also, because micro-hydro power facilities do not depend on dams to store and direct water, they have minimal, negative environmental impacts compare to large-scale hydro-electric stations.

Additionally, by reducing the need to cut down trees for firewood and contributing to increase farming efficiency and other small-scale economic enterprises in rural settings, micro-hydro power has a positive effect on the local environment, and is an effective climate change mitigation technology.

Technology Characteristics	
Features	One of the greatest limiting factors in the transformation of the Douglas D'Silva Station into an Eco-Tourism, Research and Education Facility is the unreliable source of electrical energy produced by an old Lister diesel generator. Energy is intermittently provided for a three to four-hour period. For the station to be converted into a tourist resort and education/research centre, it would require that the system be upgraded requiring greater output than can be provided by the present generator, and a more reliable source of energy. An assessment of the available alternatives sources of energy indicate that the facility's needs could best be met through a small hydroelectric plant. The hydrology and topography of the

	area, with its abundance of creeks and tributaries of the Macal River, is suitable for this renewable technology of minimal environmental impacts. The Mountain Pine Ridge Micro-Hydroelectric project is projected to generate electric power of 110/220 V, utilizing the waters of the Rio On river by means of a micro hydroelectric power station with a total installed capacity of 75 -100 kW. The aim is to improve the supply and quality of the electric service in the Douglas D'Silva Forest Station (DDSFS) and the proposed plans to convert the DDSFS into a model Eco-Tourism, Education and Research facility (Tunich Nah, 2004). It is expected that this improvement in providing a reliable source of affordable electricity will allow the transformation of the Station into an Eco-Tourism, Research and Education Centre. The DDSFS, also known as Augustine Forest Station, is the administrative centre for all operations within the MPRFR, the Eligio Panti National Park, the Chiquibul Forest Reserve, the Chiquibul National Park and the Thousand Foot Falls Natural Monument. The activities currently being carried out at the station include sustainable forest management, minor reforestation programs, watershed protection, eco-tourism development, development of two recreational sites and facilities, research, education, Southern Pine Bark Beetle monitoring and control, forest fire management among others. However, budget allocation for all these activities is limited, and hence is a major constraint to realize the fundamental objectives of sustainable forest management, carbon emission reduction through reforestation, and generation/utilization of renewable energy.
Capital Investment Cost	The total cost of the project including the items previously described and utilizing **3 x 25 kw turbines costing** **US$ 396,470.00**. The cost breakdown is presented in **Table 1 below** **Total cost of Douglas D'Silva Forest Station project** Description Cost (US$) Civil works $ 174,475 Roads and access $ 15,000 Electro-mechanic equipment $ 162,975 Construction Phase interest $ 10,275 Project supervision $ 33,745 **TOTAL** **$ 396,470**
Operating Cost	Operational cost for the 3-year project cycle is US

	$30,000.00 per year
Maturity	Micro hydroelectric generation technology has been in used from the 1970s.
Country Specific Applicability and Potential	
Status of technology in country	Blue Creek village micro hydroelectric power facility on the Rio Bravo became operational in the 1980s. This system was generating, at its production peak period, about 100 – 250 kW. This facility became redundant and was decommissioned after the area was connected to the national grid in 1992.
Market potential	The transformation of the DDSFS into a model Eco-Tourism, Education and Research Facility in accordance to the MPRFR Master Plan will provide and create new job opportunities for members of nearby communities of San Antonio, Cristo Rey, Seven Miles Village and San Ignacio (De Veries, 2004). The MPRFR Visitor Use Master Plan calls for Public-Private administration of the proposed Eco-Tourism Education and Research Facility. However, the installation and operations of the micro hydroelectric plant will be the responsibility of the Forest Department in the Ministry of Agriculture, Forestry, Fisheries, the Environment and Sustainable Development, which manages the reserve within which the forest station and the project site area are located. The market potential of the micro hydroelectric facility will indirectly stimulate the local tourism market, enhance sustainable forest management and research. The technology itself can be replicated or adopted in other tourist/forestry /agriculture enterprise, that may benefit from the economic and environmental spin off of an 'eco-tourism/green technology label'.
Scale of application and time horizon	The micro hydroelectric facility technology transfer under the TNA initiative will be sited locally in the DDSFR Eco-Tourism, Education and Research Facility, serving the wider operations and sustainable forest management of the Mountain Pine Ridge Forest Reserve (MPRFR). The time horizon for the micro hydroelectric facility will be 25 years.
Institutional and Organizational requirements	The Forest Department in the Ministry of Agriculture, Fisheries, Forestry, Environment, and Sustainable Development, will be the governmental body directly responsible for the installation, operation and maintenance of the MPRFR micro-hydroelectric facility on the Rio On. Other governmental and quasi-governmental agencies who will have a stake in this development include: Ministry of Tourism, Ministry of Natural Resources, and Ministry of Defence. Statutory

	bodies include the Protected Areas Conservation Trust, the Belize Tourism Board, and the Institute of Archaeology.
Operation and maintenance	The Administration, operation and maintenance of the Douglas D'Silva Forest Station micro hydroelectric plant will be the direct responsibility of the Forest Department.
Scale/size of beneficiary group	The average, annual number of visitors (Belizean and non-Belizean) to the Mountain Pine Ridge Forest Reserve tourist destinations and trails between 1995 and 2002 was near 150,000 (Tunich, 2016). The figures showed that in 2002, about 38 % of the total number of visitors were Belizeans, and 62 % were of other nationalities. In 2015, the total number of visitors was . Visitors include tourists, foreign student research groups, non-national researchers, Belizeans and Belizean students, family groups, governmental and private sector officials and workers, tour guide agency representatives, and others. An upgraded DDSFS Eco-tourism, Education and Research Centre will attract even more visitors with the increasing number of tourists travelling to Belize.
Acceptability to local stakeholders	An improved and reliable, renewable, electric power supply system produced by the proposed micro hydroelectric facility on the Rio On is a recommendation proposed in the Mountain Pine Ridge Forest Reserve Visitor Use Master Plan (De Vries, 2004). Local stakeholder's consultations on the Plan fully support the improved electrification of the Douglas D'Silva Forest Stations Tourist and Education Centre.
Endorsement by experts	All the experts in forest management, tourism and other productive sectors in the area of the Mountain Pine Ridge Forest Reserve, including policymakers in related sectors endorse the micro hydroelectric energy facility for the DDSFR Tourist centre.
Barriers and Disadvantages	Some barriers and disadvantages to the procurement, installation and operation of the proposed 100 – 150 kW micro hydroelectric system for the Mountain Pine Ridge Forest Reserve visitors centre include: initial cost, reliability of the system under extreme conditions, capacity for maintenance, high cost of spares and equipment, life of technology may be too short, technology may become obsolete and need for replacement before projected time horizon, sustainability after 4-year of project cycle, insufficient flow during drought years, tropical cyclone impacts, forest fire damage to 2.5 km transmission lines
Climate change mitigation Benefits: Hydroelectric power systems is a renewable or clean form of energy that have almost zero emissions, except for those larger facilities with large	

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<tr><td colspan="2">reservoirs inundating vast, vegetative zones. Smaller, run-of-the-river micro hydroelectric systems have proven to be more efficient and cause less impacts to the environment.</td></tr>
<tr><td colspan="2">Mitigation potential: The mitigation potential of a 75 – 100 kW renewable energy generator is in the order of approximately 134.1 lb. of Carbon offset for 100 kWh of generated electricity, or 0.0608 tonnes CO_2 (source: www.better-world-energy.com).</td></tr>
<tr><td colspan="2">Potential Development Benefits: Economic, Social, Environmental</td></tr>
<tr><td>Economic benefits</td><td>The economic benefits of a reliable and renewable energy supply for the DDSFR Eco-Tourism, Education and Research Facility will prove to be far-reaching across various productive and recreational-based sectors. Main income sources will be from Entrance, Rentals and Activities.

Preliminary estimates have this figure at US $ 104,257.5 annually, using a middle-earning estimate for selected activities and a wide split entrance rate of US $1.50 for Belizeans and US $ 5.00 for non- Belizean (De Vries, 2004).

The Forest Department will need to hire at least four full-time, certified, micro hydroelectric technicians, and four certified electricians. An additional 5 labourers will need to be hired for the construction and installation phase of the hydroelectric plant.</td></tr>
<tr><td>Social benefits</td><td>The establishment of the DDSFR Tourist Centre will require joint administration by the Forest Department and Private Sector partners. Once the micro hydroelectric plant is up and operational, this will stimulate the local economy and provide much need jobs for persons from most of the buffer communities, and other communities in the Cayo District.</td></tr>
<tr><td>Environmental benefits</td><td>Compared with other forms of electric power generation for small enterprise like the proposed Douglas D’Silva Forest Station Eco-Tourism, Education and Research Facility, a micro hydroelectric power facility is one of the better options, with insignificant environmental impacts.</td></tr>
<tr><td colspan="2">References:

De Vries, G.W. 2004: Visitor Use Master Plan for the Douglas D’ Silva Forest Station in the Mountain Pine Ridge. Ministry of Natural Resources, the Environment, and Industry Cayo District. Belmopan City, Belize.

Practical Action, 2015: Micro-hydro Power: How it works, Impact. http://www.practicalaction.org/micro-hydro

Tunich Nah, 2008: Feasibility Study for Renewable Technology (Micro-Hydroelectric Facility) for Douglas D’ Silva Forest Station in the Mountain Pine Ridge, Cayo District. Belize.</td></tr>
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