Michigan Tech
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Micro Hydropower Design

Cerro Piedra, Comarca Ngöbe-Buglé, Panama

El Tigre Engineering

Mission Statement

"To develop an economically and environmentally sustainable hydropower design to the communities of Mamey, Cerro Piedra, and Arena of the Comarca Ngöbe-Buglé, Panama in order to provide a better quality of life."

Background

Cerro Piedra, Quebrada Arena and Quebrada Mamey are three separate communities working with Jake Midkiff, Peace Corps Volunteer and Master's International Student. The communities consist of 456 indigenous Ngöbe people in approximately 70 homes.

The communities are located amongst treacherous hills and densely forested land with no running water or electricity. This creates many challenges for the self-sustaining farming communities in their daily tasks.

Methods

El Tigre Engineering surveyed various locations and elevations along the river for an optimal hydropower system. A cloth tape was used to obtain measurements of the pool characteristics and various other profiles. To determine the velocity of the river, the float method was used upstream of the waterfall. A depth profile was created and combined with the float method to determine the flowrate. A hand-held Global Positioning System (GPS) was used to indicate way-points along the footpaths in the communities for potential transmission line layout. These were later uploaded into Google Earth to create a map for distribution. Instead of setting a goal for an amount of power to be achieved, or a cost limit, the project objectives aim for dependability and simplicity.

Unique Inlet

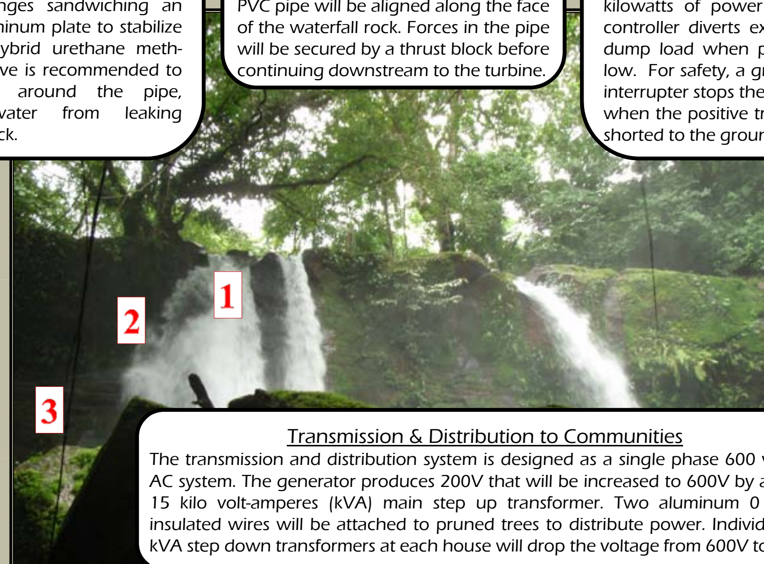
Behind the rock face of the waterfall lies a natural pool through which the inlet will extend. A screen consisting of 1/8th inch holes drilled into the PVC pipe will prevent debris from entering and damaging the mechanical equipment. The inlet will be anchored with solid flanges sandwiching an 1/8th inch aluminum plate to stabilize the inlet. A hybrid urethane meth-acrylate adhesive is recommended to fill the void around the pipe, preventing water from leaking through the rock.

PVC Penstock

The penstock is made of schedule 40 PVC pipe, painted with a water based latex paint for UV protection. Anchored with #3 reinforcing steel, the PVC pipe will be aligned along the face of the waterfall rock. Forces in the pipe will be secured by a thrust block before continuing downstream to the turbine.

Turbine/Generator

Water in the penstock flows to the turbine where it propels the blades, spinning a shaft connected to the generator. The rotating magnetic field inside the generator converts mechanical energy to transmittable electricity. The generator produces 15 kilowatts of power at 200 volts. A controller diverts excess power to a dump load when power demand is low. For safety, a ground fault circuit interrupter stops the flow of electricity when the positive transmission line is shorted to the ground.



Transmission & Distribution to Communities

The transmission and distribution system is designed as a single phase 600 volt (V) AC system. The generator produces 200V that will be increased to 600V by a single 15 kilo volt-amperes (kVA) main step up transformer. Two aluminum 0 gauge insulated wires will be attached to pruned trees to distribute power. Individual 0.5 kVA step down transformers at each house will drop the voltage from 600V to 120V.

Results

Power calculations, based upon head and flowrate at this site, show a potential power generation of 15 kilowatts at a 50% equipment efficiency. A single transmission distribution system would provide 40 houses with an average of 340 watts of electricity. This is enough to run three 100 watt light bulbs constantly in each home. The transmission lines would extend 2.5 miles to reach approximately half of the homes. Below the cost estimates for two options are provided. These estimates include materials needed for construction. The Toshiba option is based upon a manufactured turbine and generator. The Crossflow option would require a home built turbine and an induction motor as a generator.

Cost Estimates

Toshiba Turbine Option

Category	Total Cost
Mobilization	500
Inlet	8,000
Penstock	11,000
Mechanical Equipment / Housing	70,500
Power Distribution	15,000
Total Cost	*$105,000*
including 7% tax	**$112,350**

Crossflow Turbine Option

Category	Total Cost
Mobilization	500
Inlet	8,000
Penstock	11,000
Mechanical Equipment / Housing	2,000
Power Distribution	15,000
Total Cost	*$36,500*
including 7% tax	**$39,055**

Recommendation

The home built Crossflow option is simple, durable, and economically preferable. The Toshiba option will eliminate errors in manufacturing but is cost prohibitive. It is not economically feasible for these communities to purchase the Toshiba or supply power to every home unless grants and additional funding becomes available.

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