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Implementing pico-hydropower sites in rural Rwanda

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Abstract

Dartmouth Humanitarian Engineering's Hydropower Project seeks to implement small-scale "pico" hydropower in remote communities around the world. These smaller systems produce under a single kilowatt (kW) of power, and are capable of charging car batteries that can be distributed to community members. These rechargeable batteries are rented out through a battery box kiosk station, which is run by a member of the community. Once DHE's Hydropower group arrives in country, the team begins installation, which includes training local technicians to operate and maintain the site and the kiosk. DHE has utilized an iterative design process in developing its proprietary Pelton turbine design, aided by the assistance of graduate-level work done over 2011. The project has installed and helped maintain three turbines in Rwanda over the past five years.

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1. Introduction

Rural electrification has the ability to improve the standard of living of individuals who inhabit remote regions of the world. Currently, costly non-renewable resources such as firewood or coal provide most rural energy. While hydroelectric power is often feasible to help bring electricity to an area that cannot be reached by established infrastructure, large-scale hydropower can be damaging to the environment and is impractical for many communities due to high implementation and installation costs. Dartmouth Humanitarian Engineering works to counter this opposition by introducing small-scale hydropower to regions unable to access grid-based electricity.

Dartmouth Humanitarian Engineering (DHE) was founded in 2004 in response to the growing need for global poverty reduction and student demand for service and engineering opportunities abroad. Today, DHE is an award-

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winning, impact-driven group of university students who are committed to making a difference through small-scale, sustainable solutions. We run a variety of technical projects in developing nations focused on providing fundamental needs. These include small-scale hydropower systems, improved cookstoves, and increased access to clean biofuels.

In this paper, the history, current status, and projected future of Dartmouth Humanitarian Engineering's Hydropower Project are described. Special focus is paid to DHE's technology and the metrics and analytical tests used to validate the Hydropower team's technical design choices. The paper also describes the community-driven business model used to integrate DHE's hydropower technology into rural areas, as well as the safety concerns and social impact associated with in-country implementation.

1.1. History

DHE's Hydropower Project began on Dartmouth's campus in 2007 when students at the Thayer School of Engineering developed a system to provide small-scale hydroelectric power using a water-driven turbine and low-impact river diverting technology. After refining the design to facilitate sustainable, long-term integration into rural environments, the team identified the Wildlife Conservation Society (WCS) in Rwanda for support. In 2007, only 1 in every 100 rural-based Rwandans had access to grid electricity, meaning there could exist strong demand for our environmentally-conscious solution. We received support from WCS, the Kigali Institute of Science and Technology (KIST), and the local community of Banda, Rwanda to implement our first pico-hydropower system in 2008. Initially, the purpose of the project was simply to set up a working hydropower site exclusively using locally-sourced materials.

The Hydropower team completed a successful implementation trip in 2008, ultimately installing one turbine purchased from a Canadian company and one locally fabricated turbine utilizing cut pipes. We soon realized, however, that the locally fabricated turbine was suffering from significant inefficiencies related to its design. In 2011, a new Hydropower team returned to Banda to carry out upgrades on the site as well as conduct impact analysis surveys, making use of the time between to improve our technology and communicate with like-minded organizations worldwide to improve our electricity distribution design. The 2011 upgrades consisted largely of implementation of a new turbine designed by a Thayer School of Engineering student as part of an upper-level engineering course.

The following year in Summer 2012, DHE traveled to Rugote, Rwanda to install a third hydropower site. That year, our team of engineers collaborated with a student group called e.quinox from the Imperial College London. Together, the groups designed and constructed the new site, which is considerably larger and can accommodate up to 5.0 kW of power generation. Most importantly, a strong business model was successfully executed, forming a powerful union between environmental and social sustainability that followed the process from electricity generation at the turbine to the distribution of charged car batteries in the village center.

1.2. Current Operations

In Summer 2013, DHE sent a team of six undergraduate engineers to Banda, Rwanda to ensure the durability of our two hydropower sites. The primary focus of this trip was to upgrade the electrical systems at both sites, which required a redesign, as well as install a more robust turbine and electrical generation system, called the Powerspout. The Powerspout is a Pelton turbine manufactured by EcoInnovation. The Powerspout can produce up to 1.0 kW of power and is available in multiple configurations, making it adaptable to various landscapes. The turbine is manufactured from 68% recycled parts and boasts no exposed wiring or rotating parts.

Beyond the turbine design and physical project site, 2013 marked the first year that a small subset of the project team was dedicated to studying both the business plan and the social impact of our work. The data collected in Rwanda was then analyzed at DHE headquarters in Hanover, NH by our Impact Analysis team.

2. **Technology and Hydropower System Design**

The general principle behind hydropower is that falling water has potential energy. As the water falls, that potential is converted to kinetic energy, which can be captured and stored as electricity. Every site that we install