Tech Expo, Spring/Fall 2026 – Team 44

Hydroelectric Generator

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Problem Statement

Off-grid communities lack access to reliable electricity. Existing hydropower technologies aren't suited for low-head, low-flow applications and commercially available systems are too costly or complex to maintain locally without upkeep. The absence of portable, easy-to-maintain modules leaves households without a practical solution to generate passive, affordable energy.

Customer Background

The client for this project is focused on addressing the lack of reliable electrical access in small, remote communities located in the Peruvian Andes, particularly within regions such as the Colca Valley. These communities are geographically isolated, making connection to the national power grid impractical and leaving residents dependent on inconsistent and environmentally harmful short-term energy solutions. The client aims to improve living conditions by leveraging locally available renewable resources, including river currents and geothermal heat, to generate sustainable off-grid electricity. Due to limited technical infrastructure and resources in these areas, the client requires solutions that are affordable, portable, durable, and simple to maintain without specialized expertise. Additionally, the client emphasizes minimizing environmental disruption, especially to water flow and local ecosystems that are critical for irrigation and daily life. Overall, the client's goal is to enable long-term social, economic, and educational development through accessible and reliable renewable energy technology.

Requirements

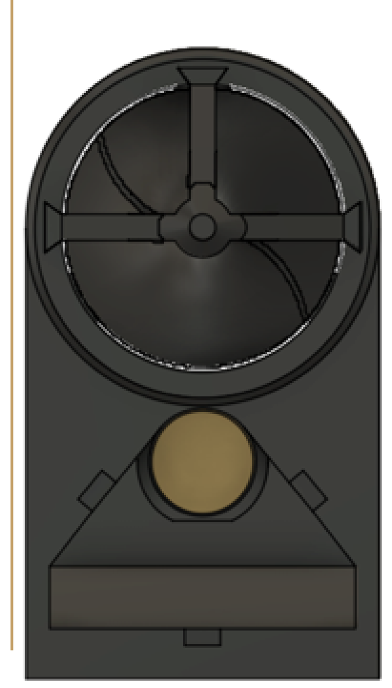
The hydroelectric generator must be designed as a low-cost, sustainable, and reliable energy solution for remote communities in the Peruvian Andes. A primary performance requirement is that the system must generate a minimum output of 4 volts to provide usable electrical power for small devices, charging applications, or basic lighting needs. The generator should be capable of producing this output using natural river or stream flow under varying water conditions. Portability is another critical requirement. The unit must be lightweight, compact, and easy to transport so it can be carried into remote areas without the need for heavy equipment or complex installation. This allows the system to be deployed in isolated mountain communities where access is limited.
The design must also be durable enough to operate in harsh outdoor environments, including exposure to water, debris, and changing weather conditions. Electrical components need to be sealed and waterproofed to ensure safe and reliable performance. In addition, the generator should be simple to assemble, operate, and maintain so that non-technical users can use it with minimal training. To support long-term use, the system should use affordable and readily available materials whenever possible, while incorporating modular components that can be easily repaired or replaced. Overall, the generator must balance low cost, portability, durability, and a minimum 4-volt power output to meet the needs of the target communities.

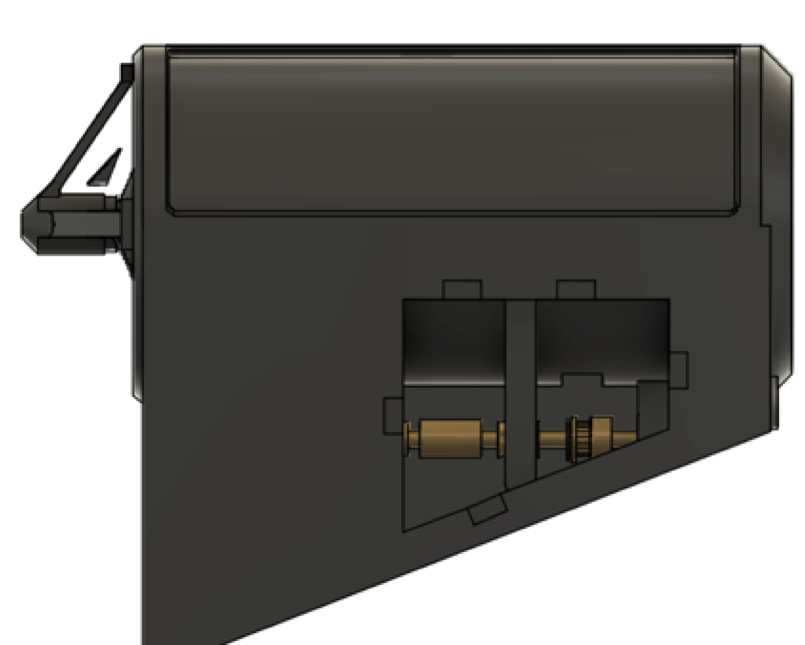
Experimentation and Concepts

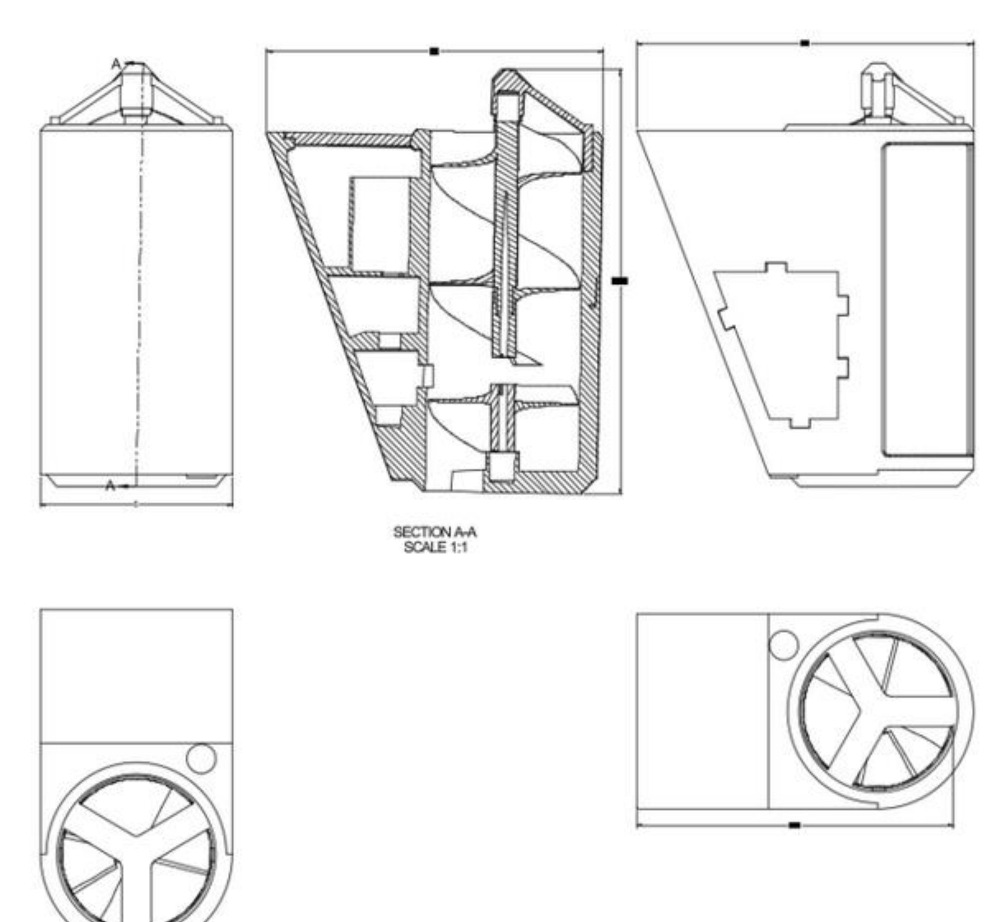
The experimentation focused on applying fundamental principles of fluid mechanics, thermodynamics, and energy conversion to evaluate system feasibility. For the microturbine, flow rate and water velocity concepts were used to estimate torque, rotational speed, and expected electrical output under realistic river conditions. Turbine blade geometry and placement were tested conceptually to maximize energy capture while minimizing obstruction to water flow. Calculations were performed to compare theoretical power outputs with realistic efficiency losses. These experiments and analyses guided design decisions to ensure the final system balanced performance, simplicity, and environmental responsibility.

Final Design

The microturbine works by converting the natural kinetic energy of flowing river water into electrical energy in a simple, low-impact way. As water flows through the stream, it passes over the turbine blades, causing them to rotate without the need for dams or large elevation drops. This rotational motion spins a connected shaft, which drives a small generator housed within the turbine assembly. Inside the generator, the mechanical rotation is converted into electricity through electromagnetic induction. The generated power is then regulated and stored or distributed to meet local energy needs. Because the turbine operates continuously as long as water is flowing, it provides a steady and reliable source of renewable electricity while preserving the natural behavior of the river. The design prioritizes portability, allowing components to be transported and installed using minimal tools and local labor. Durable, low-maintenance materials were selected to ensure long-term operation in harsh environmental conditions. Overall, the final design delivers a sustainable, environmentally conscious solution that meets the client's goals of affordability, reliability, and community-level energy independence.







Testing and Results

Testing was conducted by operating the microturbine under controlled conditions with a water flow rate of 5 gallons per minute to simulate realistic stream conditions. Electrical output was measured using a multimeter connected directly to the generator terminals. During testing, the system consistently produced an output voltage of approximately 4.4 volts. This voltage confirms that the turbine successfully converted the kinetic energy of flowing water into usable electrical power. The output is routed through a buck/boost converter, which steps the voltage up to a stable 12 volts suitable for practical applications. These results demonstrate that the system can generate sufficient and adaptable power at relatively low flow rates, supporting its feasibility for use in small, remote waterways.