The Archimedes Initiative

Problem

Worldwide, 783 million lack access to clean water. 319 million of them reside in Sub-Saharan Africa. In this region, the transportation of water can be challenging using current methods. People in developing communities must travel great lengths to retrieve a few gallons of water on a daily basis. Due to the lack of infrastructure and no external source of energy, new methods to transport the water must be capable of generating their own energy.

Introduction

The Archimedes initiative set out to provide water to those without access.

- Centered on the comparison of a fully-mechanical and a mechanical-electrical hybrid system
- The project will investigate the effectiveness of each system. Considerations such as price, modularity, complexity, and ease of use have been taken into account with the aim of creating an effective, efficient, easily repaired design.

Deliverables

- 5-10 L/min
  The use of the system will determine the flow rate – a irrigation system will require a greater flow rate than a potable water system.
- 1 mile Flow Distance
  The flow distance will also be based upon the needs of the consumer. A mile was chosen to evaluate feasibility.
- 60 ft. Vertical Head
  The vertical head will account for an elevation gradient over a given region. 60 feet was chosen as the beginning deliverable to prove an elevation gradient could be overcome.

Mechanical

Starting the Design

The Mechanical Team’s design consists of two separate pumping stations. The first station uses a vertical rope pump to lift water from water sources up to 50 ft below. The water is pumped into a holding tank, from which it enters the second station: the Archimedes Screw. This structure rotates along its long axis, moving the water diagonally to a second holding tank 8 ft off the ground.

Rope Pump

The rope pump is secured by an A-frame (right), positioning it above a water source or well. Rubber gaskets attached along the rope are used to push water up through a long pipe. At the top opening of the pipe, the water is deposited into the first holding tank.

Archimedes Screw

The Archimedes Screw (above) is centered around a 12 ft long, 4 inch diameter PVC shaft. Vinyl tubing spiraling around the PVC shaft transports water along the length of the shaft when the structure is rotating.

Water Storage

The water storage is designed to use the water pressure of the stored water to send the water through pipes to the next water storage station. The first water storage station is accessed by the lower end of the Archimedes Screw, and is located at ground level. The Archimedes Screw deposits water into the second water storage station, an 8 ft tall vertical tank (left).

Wind Turbine

The design utilizes the Savonius wind turbine to power both the rope pump and the Archimedes Screw. With an average wind speed of 6 m/s and a radius of 2 meters for the sail of the turbine, we will put out ~50 Nm of torque which will run either pump.

Hybrid

Starting the Design

The goal of the hybrid team is to design and assemble a working electric pump system. First, a well pump that could meet the design requirements was selected, and a power system was designed around that pump. Originally, wind power was to provide power to the pump but upon a cost analysis between wind power and solar power, it was decided that solar power was the best option.

Pump Selection

The best option for this type of water transport is the well pump. The pump selected is the Red Lion RL-15015-W0V. It has a high maximum head which is needed to not only move the water from the well to the surface, but it also allows for changes in elevation. It provides substantial flow rate that ranges between 10-20 gallons per minute. With this flow rate, the pump only needs to run about 1 hour each day.

Battery Bank

The battery bank consists of 24 12 V deep cycle lead-acid batteries. These batteries are an ideal option because they are designed to be regularly charged and discharged rapidly. Other types of batteries were considered but the cost of these were often outside the team’s prototype budget. The 12 V DC from the batteries is converted to 240 V AC that the pump needs as a power supply

Solar Panels

It was decided to use 3 100 W Renogy solar panel and a Renogy charge controller to charge the battery bank. These will provide more than enough power to meet the power requirements of the pump.

Pump Operation

The system will use a charged water tank and a pressure switch in order to operate autonomously. The pressure switch will turn on the pump when the water pressure drops below 30 PSI and it will turn off the pump when the water pressure rises to 50 PSI.

Discussion

Initial observations have shown a stark contrast in the abilities of each of the systems.

Hybrid

- More effective in transporting water, however contains inherent cost and maintenance hurdles
- May not be suitable for the target environment due to relatively delicate electronic components
- Current design will meet and exceed the power and pressure requirements.

Mechanical

- Better suited for the target environment due to its lack of electrical parts
- Reliable and consistently provides water as long as there is steady wind
- Uncertain if the entire system will be capable of producing the required powered to transport the water vertically.

Future

Testing

- Components will be tested to determine its quality and efficiency
- Repeated testing as the systems are assembled in an effort to quantify the efficiency losses.
- Post-assembly, the two systems will potentially aid Project Haiti in the transportation of water. In this endeavor, it will be possible for the system to undergo further physical testing and modifications.

Future Research

- Further research will need to be completed on gear ratios and differentials to maximize efficiency and optimize the power transfer from the turbine into the pumps.