Low Budget Energy for the Third World

A Prototype Powered by Water Runoff

Tag Words: renewable energy; water power; water filter; Haiti; energy source; lifestraw; soccket ball

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Summary:

We have designed a device made from accessible repurposed materials (PVC pipes, wire) that would harness the energy captured from water run-off. Energy is generated by water running through a small water turbine inside a PVC pipe. The water is then purified as it passes through filters of different size and composition (carbon and iodine). Our intent was to design an affordable and easily constructed product that would provide both drinking water and energy to the global population without such amenities.

Video Link: http://youtu.be/p0WEUqLpGTk

Shortage of Fresh Water in Third World Countries (DC)

According to the Millennium Development Goals Report 2012, “783 million people, or 11 per cent of the global population, remain without access to an improved source of drinking water. Such sources include household connections, public standpipes, boreholes, protected dug wells, protected springs and rainwater collections.” One problem that a lot of third world countries have in common is the shortage of drinking water which creates great conflicts between nations and ethnic groups within nations. Ismail Serageldin, vice-president of the World Bank stated in a 1995 New York Times article that "The wars of the next century will be about water." Water is involved with the growing of food, waste disposal, industrial practices, transportation, and survival which isn’t news to nations in third world countries. They understand the need for these water resources and are willing to fight for them. Conflict normally arises when two nations sharing a common water resource start to run out of their other resources and start relying more on the shared body of water. One nation will threaten the other with the hopes of scaring them into handing over the water resource. However, this may be followed by a responsive threat which could lead to war. If they don’t die from humans attacking one another over the water resource, they may die from the poor quality of the water.

Half of the population of the developed world suffer from one or more of the six main diseases associated with water supply and sanitation. These diseases are as follows, 1. diarrhea—caused by a number of microbial and viral pathogens in food and water; 2. ascaris, 3. dracunculiasis, 4. hookworm, and 5. schistosomiasis, all by infestation with various worms leading to disability, morbidity and sometimes death; and 6. trachoma—caused by a bacterium, leading to blindness. Around 400 children below age 5 in the developing world die from waterborne diarrheal diseases. Wells are the primary source of water in third world countries, but
there aren’t many. Standing and surface water typically carries waterborne infectious diseases. People frequently have to carry heavy loads of water on their back for sometimes miles back to their rural villages from such sources. Water from wells is more sanitary but maybe limited so other filtrations need to be considered.

The World Health Organization doesn’t directly recommend water quality standards only guidelines. In order for water to be potable or drinkable it has to have acceptable quality in terms of its physical, chemical, and bacteriological parameters so it can be safely used for drinking and cooking. A person weighing around 132lbs should drink 2 liters of water daily. This is not set in stone and weather and climate play a big role in how much water you should drink. Water needs are increased as the temperature exceeds 77 degrees Fahrenheit mainly to make up for moisture loss through perspiration (1-4).

**Energy Problems in Third World Countries (DC)**

Overall, at least 1.6 billion people or one-fourth of the world’s population is currently living without some sort of electricity or power. Electricity is used in daily lives for simply pleasures such as reading at night all the way to pumping minimal amount of drinking water to survive. Think of it this way, one-fourth of the world lives in total darkness once the sun goes down and rely on candles to guide them. They have no access to electricity, and a billion more have only an unreliable supply. For those that live without power live in rural areas or outskirts of cities. The United Nations estimated the cost of $35 to $40 billion a year to give everyone on the planet the ability to cook, light, and have electric at their command. Instead of having electricity at their fingertips, they cook with over wood fires. It provides heat for housing when the temperatures drop and is a source of light. Cooking done over an open fire can create a safety hazards, but is also an environmental concern leading to deforestation and greenhouse gas emissions (5).

**Novel Solutions to Water and Energy Shortages**

**LifeStraw (DC)**

This water filter is designed to be used by one person to filter water so it is safe to drink. It filters a maximum of 1000 liters of water which is enough for one person to drink for a year. Removing 99.99% of waterborne bacteria and 99.99% of parasites this filter is perfect for third world countries that don’t have clean drinking water. This plastic tube is 310 millimeters long and 30 millimeters in diameter. The way it works is water is drawn up through the straw first passes through hollow fibers and several filters that filter water particles down to .2 microns across. The first is a textile pre-filters. The tiny opening is the mesh of the filter measure 100 microns in diameter. This filters out the bigger particles, like dirt and sediment. Next the water passes through a polyester filter. The holes in the mesh of this filter are much smaller. This filters out clusters of bacteria. From there, the water moves through a chamber of beads that are impregnated with iodine. This kills 99.3 percent of bacteria and viruses. And finally, the water passes through a chamber of granulated active carbon. Not only does the carbon improve the taste and smell of the water, it should also filter out any remaining parasites.
Before starting our intense design and build process, we wanted to examine other alternative energy products designed for the 3rd world. The Soccket Ball was an easy research topic due to the amazing design story behind it. It is a ball that harnesses and stores energy from active movement for later use as a portable power source. This is not an ordinary soccer ball and was designed by four students from Harvard. Ironically, this design followed along the lines of our idea it was also made for a very similar class to ours. Starting the same way as us, the group wanted to identify a problem in the world and create a solution to it while being sustainable and eco-friendly. Their research led them to find 1 out of 4 people worldwide live without access to reliable electricity. With this information and their motivation to make a working device that was also a fun and usable one, they created the Soccket Ball.

The first design for this alternative energy ball started with a magnet and spring energy mechanism, or an inductive coil method. This idea produces energy simply by using a metal spring with a magnet sliding inside which is the same way a ‘shake-to-charge’ light would work. Besides creating power they needed to figure out how to put the power producer in a regular
sized ball as well as a energy holder. Like many prototype builds, their design was not perfect the first time around and many things were changed to perfect the design through their long journey. Things inside and outside of the ball changed over time such as the AC adapter converting to a DC jack in order to open up the range of pluggable options to the ball. The exterior of the ball was changed to help keep it waterproof while keeping it as similar to a real soccer ball feel. The biggest change that was done was to the heart of the design which involved changing the way the ball created the energy. Going from the inductive coil method that only could provide energy from certain directions they used a method that would increase the average volts 1,000 % greater. The new energy producer inside the ball is a gyroscopic mechanism that can create energy from all possible dimensions of motion. This newly patented design can power a light for up to 3 hours off of just 30 minutes of play.

While one of their goals was to be eco-friendly they managed to make the ball 95% recyclable. Solving this problem the way they chose not only created an alternative energy device, but it also lessened the use of the current light source, kerosene lamps. Not many people may know that the use of kerosene lamps is not only bad for the persons around it, but it is also harmful to the environment. Kerosene lamps used for lighting in 3rd world countries produces the same carbon dioxide emissions as 38 million automobiles. Like we plan to do, their idea successfully solves more than just one issue in an undeveloped area. They also went on to use a ‘buy-one-five-one’ business strategy which helped give the product to much needed people around the world.
Before coming up with a novel product, we thought it would be good to look at different types of turbines and how one may work better, or different than others. Basically there are two types of water turbines, reaction turbines and impulse turbines. The more common of the two is reaction turbine, which can be powered directly by water pressure. The reaction turbine absorbs this pressure from the water current through its direct impact with the turbine runners. They are best in water conditions where there is a low head, with a high flow. The use of ‘head’ refers to the specific measure of the liquid pressure. This means they are better at catching energy when there is not enough head to create a high pressure jet.

The impulse turbine creates a high pressure water jet with the incoming water flow. They are best used in water conditions where there is a very high head with a small amount of flow. Due to this more rare water flow type this causes the application of the impulse turbine to also be low. On the other hand when this turbine is applied in the correct conditions it creates a very large amount of energy.

After learning about these two types of turbines it was on to the different types of turbine runners (fan/buckets/blades). There are four main water turbine runners are the Pelton Wheel, two different Francis Turbines, and the Kaplan Turbine. The Pelton Wheel extracts energy from the impulse of the water flow making it an impulse turbine which creates an average speed of 5 rmp. The Francis Turbines is an inward flow reaction turbine which combines both radial and axial flow concepts creating a higher speed at 30 & 70 rpm. The last type of runner is the Kaplan Turbine. This turbine type creates the highest speed at 113 rpm with a propeller that uses adjustable blades to achieve efficiency over a wide range of flow and water levels.

With information gained from this research, we are looking to use a reaction turbine type with a Francis Turbine runner. Since the source of our water is roof runoff that is not necessarily
going to have extreme pressure, reaction turbine fitted our needs the best. After looking at all the runner options we wanted the fastest spinning but also needed a runner that would have the highest surface area for the water to hit. In our situation our best option was as said the Francis Turbine runner.

References 12,13,4,15,16

Repurposing Materials (JI)

In the creation of our design we wanted to be as sustainable as possible using sustainable materials that would generate and harness the energy. Being that our intended design harnesses the power of moving water, we needed something to contain the water. For this we planned on some type of piping. Next we needed a power generator to convert the water movement into electricity. We also needed something that would cause the moving water to spin the generator as just pouring water on top of the generator didn’t quite work. After looking at different designs, we decided upon using a fan like piece that will spin when water is passed through it. A fourth major piece of our design was finding a way to harness and store all of this energy, so that the device does not need to be running every time electricity is needed. The last major piece of the puzzle was to be able to transmit all of the electric from one part to the other. For this, wire of different sorts would be needed. We hoped to create our entire product using recycled resources. This way it will keep the price of building low while also being sustainable by repurposing materials that would otherwise be in a dump.

One material we thought we could use was leftover PVC piping from construction sites. These pieces would be thrown away because they are not long enough to do anything with. Being that our plan was to make our power generator compact, we would only need these small leftover materials. This way instead of buying large amounts of PVC and most likely ending up with waste, waste of others could be used. PVC piping is also not the only type of construction piping that could be used. It is possible that any type of piping could fit in our design. This means we could also use piping from buildings that have been demolished as well as waste from new construction sites.

Power generators can be removed from many items such as broken workout machines, cars, and motorcycles, items one might find laying in a junkyard. Cars, for instance have
alternators which use the rotation of the engine to recharge the battery in a car. Motorcycles also have something very similar. We can use the same concept with only a different source to spin the generator, using water instead of an engine.

The wiring that will be needed to complete the electrical connections is also something that can be recycled. During the demolition of buildings, wires are often left useless. Many times an object has gone bad, but the wiring inside of it is usable, as long as the metals inside of the wire have not been corroded or damaged.

Another resource that we will be able to recycle are the batteries taken out of cars, truck, and tractors. These batteries still have up to 80% of their charge left. These thrown out batteries could be used to store the energy that is produced by our generator.

One last example of something that we could use for our design are thrown out drums to hold liquid. These large plastic 55 gallon drums are thrown out all of the time and incorporate it into the design to collect rainwater. It will take something wasting a lot of space in a dump or junkyard and instead turn it into a valuable resource.

**Community Action: Building an alternative energy water turbine device out of recycled materials.**

For our community action portion of the project, we wanted to design and build an operating alternative energy device that could be implemented in third world countries who currently do not have any source of electricity. We understand that there are a number of places, such as Haiti, that are without power, but have an excess of stormwater runoff. The device must also be inexpensive so that the people in third world countries would be able to afford it. We decided to focus on a water turbine device (due to the high amount of stormwater runoff) made out of strong, affordable recycled materials or materials that could be recycled themselves. Our water turbine would use the velocity of the water flow to create usable power for the user for powering small electronics.

**3D Rhino Model**

Building the 3D Rhino Model was very important to our process. The knowledge learned from a 3D model is much more great than 2D sketches. While these sketches are important for getting the ideas out, the model helps put our ideas into a reality. To begin the model, we made a 4 “ diameter PVC pipe to see exactly how much room we had to work with. After that we worked on making the structure that would hold the turbine in place inside of the pipe. From there, we made the head that would fit onto the holder piece that would be the center connection for the turbine runners.
With the dimensions of the head, we found how much room we had to work with between the edge of the head and the inside of the 4” diameter pipe. With this dimension known, we could now divide it up between the copper, magnets, and turbine runners. We figured that with the space we had we could use ¼” diameter copper pipe and ¼” or less magnets giving the electrical components a ½” to work with. This left us with a 1 ¼” turbine runner. Although this seems very small, it also means that it is lightweight and will be optimal for high speed spinning which is what will create the actual power that can be used. While lining the interior of the PVC pipe with the ¼” diameter copper pipe, we were left with a perfect amount of space to place the unit that will bring the power from the copper to the outside. When all these pieces began to come together in the 3D model we were able to figure out more realistic ideas with how to connect all of our pieces and what we would need to make them work together and be able to move. Although the model helped a lot and was a great guide to follow during the actual build process, as expected, we encountered problems that forced us to stray from the exact 3D model details.
The Building Process

First we made a material list that consisted of, one 4” diameter 2’ long PVC pipe, one ¾” diameter 2’ long PVC pipe, one ¾” diameter 90 degree elbow PVC pipe, one ½” diameter 2’ copper pipe, and 12 small circle magnets. We used epoxy, electrical tape, and purple PVC primer with PVC cement.
We cut the copper pipe into $\frac{1}{2}''$ copper tubes so that we would eventually string copper wire through and flatten them pinching the wire in place. After marking every $\frac{1}{2}''$ down the pipe we used a cut away wheel to cut the copper into small pieces. Once we had all the pieces cut, we strung pre cut copper wire through all of the tubes and crimped them. We left about 5” of leftover wire that we can attach to the voltmeter whether we could generate power. When we were all finished with this process, we had a copper ring placed inside the 4” PVC pipe. Plastic wrap covered the ring to waterproof it. In the middle, the magnets that spun on the turbine.

Making the turbine was a meticulous process and took lots of time and precision. We focused first on the centerpiece where the turbine blades would connect. Since we were confined to a tight space these pieces needed to be extremely small which led to our decision to use a $\frac{1}{2}''$ PVC connector. After the centerpiece was chosen we then started the task of cutting and forming our actual turbine blades. Since we had our 3D Rhino model build, we knew relatively
what sizes these blades had to be (as stated earlier the original designed model changed during the actual build process). Since that was known, we then needed to find a PVC pipe that had the correct diameter to make the perfect curve of the blade. For this we used 1 ¼ “ diameter PVC pipe, and cut a little more the 1” pieces. After having 8 separate blades cut, we then needed to file one end of the blades to fit nicely to the center piece. After the blades were all fine-tuned to be as similar as possible, we then used purple primer and PVC cement to connect the blades to the centerpiece. Now that the turbine structure was finished, we were able to begin gluing our magnets onto the end of the blades. For this we used epoxy mix for its extreme holding strength.

After the turbine was completed, it was now time to make it spinnable. We searched countless stores but were unable to figure out what we could use for our spinning mechanism. We decided to use bearings from the inside of a roller blade wheel. Luckily these bearings were the perfect size for us and fit directly into our centerpiece. Since the bearings were circular, we needed a type of axle for the spinning to occur on. Our center axle was made out of a simple wood dowel.

After we had our copper piece made, the turbine blades cut and filed, the magnets epoxied to the turbine blades, the turbine blade cemented to the PVC centerpiece, and the bearings in place and working, it was now time to construct what was going to hold the turbine in place inside the pipe. For the piece that actually connected to the turbine we used a 90 degree ¼” PVC connector. On this connector is a bearing that did not move but acted more like a placeholder for the wooden dowel to go through. Connected to the 90 degree angle piece on the
other end was a smaller PVC pipe that held it up in the air. This PVC piece was placed through a hole in the larger 4” diameter pipe.

Putting this all together at the end was a pretty difficult part of the build process. Since the turbine was made with very little left over space, it needed to be placed dead center. In order to ensure accuracy, we put in all the pieces then placed many shims in certain locations to hold the turbine into place before we finally glued and cemented it in.

After assembly we now had a alternative energy device that was made by us and made with cheap and recyclable pieces. Upon completion, we went outside to test it and got a small electrical reading on our voltmeter. Although the device does not create large amounts of power, it is small enough to allow the user to apply a couple of these turbines within a single PVC pipe. Devices needing more power would be able to be used. By charging a battery bank with the energy that is harnessed. The batteries can be charged with a small amount of electrical current applied to them over a long period of time. Once fully charged, the small amount of current from the hydro device would maintain the batteries charge. This would make energy that could have been produced previously to be used at a later time as opposed to only having a direct current to an electronic device and only being able to use the electricity when the generator is running.

Because a battery produces direct current and the majority of household electronic items are wired to accept alternating current we would need to attach a power inverter. This power inverter would turn the battery into a basic household outlet. This system could be used as either a stand alone unit or connected throughout the house. The user would be able to use the electricity produced from the battery to charge phones, have lights, power a small stove, charge a laptop or any other small device that uses electricity. This system would allow the small amount of energy that our device produces to become a substantial power source to power many small, useful electronic items.
After creating the power generator, we decided to make the device just a bit more useful. By placing a filtering system similar to the lifestraw following the generator. This would take water runoff and turn it into purified drinking water.

**Public Outreach**

Getting this device to the people in need of it becomes a problem all its own. As a group we discussed how we could reach the people that might use our device (3rd world communities). We decided that the best way to connect with these communities would be through social networking and through groups that are already involved in assisting these communities. We found multiple groups pages and directly posted our video and a summary of our project to their pages. Doing this made it available to be seen by anyone visiting their page. We hope that the use of social networks like Facebook, Twitter, and Myspace will get our device to the needed locations faster and more efficiently. All leading alternative energy companies along with programs that help the third world all use these social networks to stay in touch and to stay up to date with our fast moving world. Along with the use of social networks we utilized where we also sent letters to the editors as outreach tools as well; one of which was a letter sent to is Greenstar. This organization creates community centers in third world countries while using alternative energy to run them. They’re aiding these communities as well as being
environmentally friendly, made them a perfect candidate to contact in hope of them using or helping us get our product used.

References


Letters to the Editor

Sent To: Energy Digital Global Energy Portal
Carin Hall Carin.Hall@wdmgroup.com

Dear Editor,

The lack of power in third world countries has me concerned. These countries aren’t able to run electronics to make life a little bit easier or even a reading lamp for pleasure. Along with this issue is the fact that not only don’t they have electricity they also don’t have clean, drinkable water. The death rate is significantly larger than of other countries and it has to do with the quality of water. This is a huge problem because people are dying and nothing is being done about it. Not only are they dying due to disease they are also going to war for these water resources. I have to say there are a lot of organizations that are trying to donate clean water to these countries but it isn’t a big enough effort. I understand that it isn’t easy to fix third world issues such as clean water or providing them power but there are definitely solutions that can help. This solution I’m talking about is a prototype my fellow coworkers and I have been
working on that would capture run-off water draining it to a turbine that would generate power. Immediately after this turbine it would purify the water with an intense filtering system that will produce clean, drinkable water. This prototype is still in the working stages but is intended to fit into a simple pvc pipe and be easily installed. If you would take this into consideration maybe this could be a cost efficient fix to the third world issues talked about in this letter.

Derrek Cowell
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Sent To: GreenStar (Solar Community Centers)
mjnorth@greenstar.org

Dear Michael North,

I am writing to you because I am very interested in what your website offers to the public in hope to inform them about peoples needs to express themselves in art forms. These solar power community centers you develop are amazing and I hope I can help. I am very interested in renewable energy sources and being able to produce power for people that are off the grid. Attached and below is a letter that I hope can be considered for publication. While it does not directly connect to the expression of these individuals in art forms, it touches on ways to get power to these locations which can then power these community centers.

Alternative Energy Devices for Third World Countries

When people think of renewable energy sources they imagine expensive fancy solar panels on their houses or giant wind turbines along open fields. These are both renewable energy devices, but at the largest scale possible. People continue to look past optimal energy sources because it will not produce enough power to run a city. Is that what a renewable energy device needs to do? I believe not, which is what got me interested in the topic of renewable energy sources in third world countries. Specifically my studies led me to areas with abundant water flow, such as Haiti which has an annual rainfall of 60 inches and continues to deal with flooding. These areas are in great need of power and have the renewable energy source but no device. Renewable energy devices do not need to be expensive or designed by world famous engineers. Recycled materials or even trash that is produced in America can easily be made into alternative energy devices. Plastics are constantly thrown away when they can easily be transformed into water turbines with just some time out of your daily schedule. Creating alternative energy devices with recycled materials can not only help the environment but it can make a great change in the quality of life
for people in third world countries. So get out there and turn your water bottle into something other than trash.

Matthew Pugliese
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Sent to Popular Science Magazine Letter to the Editor Department.
Email address: letters@popsci.com
Dear Popular Science,

Energy is a valuable resource that many of us could not imagine living without in our everyday lives. Although it is hard to believe for many, many people in third world countries go without having power in their households their entire lives. They can’t flip a light switch or microwave their frozen burrito to eat while they watch TV, there is no TV, no microwave, or no freezer. They cannot power even the simplest of things we consider necessities nevertheless luxuries. This is a problem that two of my classmates at and I have addressed for a class at Rutgers University and feel we need to find a solution so that these people may have electricity available to them. We have designed a piece of equipment that can be inserted into any household plumbing fixture and uses the flow of water to generate electricity. It will also be able to filter water so that it can be drinkable. Our goal is to design it so that it can be easily installed and have a low manufacturing cost, using mostly recycled materials. Our design is still in the working stage but we believe that we will be able to produce a design and prototype that can be manufactured and sent to third world countries all around the world to provide households with something we use everyday but never really think of how hard life would be without it.

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