INTRODUCTION

As part of the Northwestern University chapter of Engineers for a Sustainable World, the Nicaragua Wind Power Project has worked on campus over the past year and a half to design and test a small scale (~100W) wind turbine. The group consisted of upwards of 12 students, the majority in the McCormick School of Engineering and Applied Sciences at Northwestern. We successfully built and tested a prototype of our design and travelled to Nicaragua during the week of December 11-19, 2010 to build two turbines. The ESW-Northwestern team partnered with two Non-Governmental Organizations (NGOs), Green Empowerment (Portland, OR) and AsoFenix (Managua, Nicaragua).

One of the turbines was constructed in El Corozo, in the Tuestepe region, at their local two room schoolhouse. It was to produce approximately 200 Watts. However, a structural failure of the support tower grounded the El Corozo turbine, and several crucial parts were damaged beyond repair. Replacement of these parts, along with a structural redesign is necessary to attain functionality. The second turbine was installed in Potreritos, in the Boaco region. It was designed as a charging station, where families could bring their batteries and leave them to be charged. The support tower was redesigned in the field to avoid a structural failure similar to the El Corozo turbine.

Neither of these communities was tied to the national electricity grid. Therefore, electricity, stored in 12-volt deep-cycle batteries charged by the wind systems will be particularly useful. Electric lighting will increase the studying time for students and improve air quality in the homes by eradicating the use of kerosene lamps. Additionally, families will be able to charge cellular telephones, radios and other small electronic devices.

BACKGROUND

Wind turbines produce electricity by harnessing the power of the wind to turn blades that are attached to a generator. There are a few key components of a wind turbine. The blades are airfoils that move as a result of a difference in pressure associated with air flowing over them. The blades are attached to some kind of generator that produces an electric current as it rotates. The electric current must be utilized; typically this is done by using it to charge a battery. It is vital to have a charge controller that regulates the current coming from the turbine to the battery to prevent any over-heating or over-charging of the battery. Additionally, the blades stay facing the wind by creating a moment with a tail fin to rotate about the vertical axis. Finally, the blades and generator must be elevated and erected by some support pole so that they can benefit from the high velocity winds above the ground.
WORK AT NORTHWESTERN

A CAD drawing of the design of our turbine that was built at Northwestern is included below in Figure 1. Additionally, Figure 2 depicts the turbine during one of the days it was tested on the lakefill at Northwestern. The blades used in our turbine were made from 6 in. PVC tube. The blades were attached via a wooden hub and pulley to a ¾ in steel drive shaft. The energy from the rotation of the blades was transferred to the alternator through a set of pulleys with a ratio of 4:1 and a belt. The drive shaft was connected to the platform with two mounted bearings. A tail fin was constructed out of plywood and bolted to a five foot shaft that was attached to the platform. The alternator was suspended below the platform (see Figure 2). The other component of our design that was particularly challenging and interesting was the design of a sleeve bearing. We designed the platform to rotate by having a pipe with a smaller diameter than the support pole attached to the platform. The two pipes fit together with roughly 2mm radial difference. The annular space was filled with a sleeve bearing that drastically reduced the friction and allows easy rotation.

We erected and tested the design on two occasions at the Northwestern campus. Figure 2 includes pictures of the second test conducted by our team. During both of the tests, we used anemometers to measure and log the wind speed. There was an average wind speed of 12 mph and 10 mph during our first and second tests respectively. At those speeds we were able to achieve the voltage required to charge a 12 volt battery. However, we did not have a battery hooked up to our turbine; instead we used a variable resistance resistor to place a load on the generator.

Figure 1: CAD drawing of the design.

Figure 2: The turbine outside of SPAC on the lakefill at Northwestern University.
CONSTRUCTION IN NICARAGUA

The team travelled to Nicaragua following finals week of the fall 2010 quarter. We spent 3 days fabricating the turbines using the machine shop at the National Engineering University of Nicaragua and 4 days in the community erecting the turbines. The fabrication and design was a collaborative effort between the engineers from Northwestern and the engineers from AsoFenix.

Our design changed slightly because one of the engineers from AsoFenix is an experience welder. Fabrication with welding enabled us to incorporate new components into the design that had been difficult to do at Northwestern. We welded a yawing tube to the base of each platform that slid into the support tower tube and allowed the platform to rotate into and out of the wind. Also there was a cradle welded to immobilize the alternator. Additionally, we welded a small tube onto the top of the platform as a way to connect the tail vane. We placed and angled the tail tube such that our turbine would furl out of the high winds to protect the blades. Additionally, AsoFenix employs a carpenter who has a lot of experience making wind turbine blades, thus the blades for our design were made from wood rather than PVC.

Figure 3: On the left is the tail vane, in the middle is the platform design we used for the El Corozo turbine and on the right are the blades.

Our design for the Potreritos turbine was very similar as the platform described above, but it did not have a cradle and the blades were 56 inches as opposed to the 35 inch blades for El Corozo.

Both systems were designed to charge banks for 12-volt deep cycle batteries and we used Xantrex C60 charge controllers with dump loads to regulate the current going to the batteries. Additionally both turbines used the same design for the support tower, which was designed and fabricated by the AsoFenix Engineers. The tower was attached to a steel base secured in concrete that allowed the tower to rotate in one plane. Additionally it contained a gin pole that extends parallel to the ground and has two guy wire connections. The gin pole facilitates raising and lowering the tower for maintenance (see Figure 4).

The tower in the El Corozo design failed when we attempted to raise turbine. The piping used was too low of a schedule and failed under the moment caused by platform. This failure made us redesign the tower for the Potreritos turbine, and we essentially shorted the tower length. Figure 5 shows the erected turbine in Potreritos.
Figure 4: On the left is the tower at El Corozo with the 6 guy wires supporting it, in the middle is the gin pole design, and on right is the base design.

A more in depth description of the design and implementation of the turbines in included in a more comprehensive report of the project. Please email John Siegfried (jsiegfried@northwestern.edu) or Scott Grindy (ScottGrindy2012@u.northwestern.edu) if you are interested in more detail of the design.

NEXT STEPS

The project is ongoing, and we will continue to work with AsoFenix to improve the design and bring greater functionality. In particular we are working on improving the yawing design, improving the structural integrity of the base, obtaining proper datalogging equipment for measuring wind speed and designing a furling testing protocol.

ISEN CONTRIBUTION

The $3400 awarded for the project was used towards purchasing the materials for the turbines in Nicaragua, purchasing shop time, for the assistance of a carpenter and welder, and for ongoing maintenance.

CONCLUSION

Over the course of the last year and a half our group has had the opportunity to learn and grow significantly as engineers as a result of working on this project. Many of the group members are studying engineering disciplines that would not typically endeavor into a wind turbine project. Moreover, we spent a lot of time building and fabricating parts in the prototyping laboratory. The most valuable part of the project is that it piqued the interest of the entire group into sustainable design.