

## **AC 2010-1981: SUSTAINABLE ENERGY: A BRIDGE BETWEEN ENGINEERING, DEVELOPING NATIONS AND INNER-CITY YOUTH**

### **Paul Imbertson, University of Minnesota-ECE**

Paul Imbertson received the BS (83) MS (94) and PhD (97) in electrical engineering, all from the University of Minnesota. He has worked in power electronics for military avionics and is currently a Teaching Professor in the Electrical and Computer Engineering Department at the University of Minnesota, where he has been voted Best Professor eight times. His current interests include the wide ranging topics of energy and deciphering the minds of electrical engineering students.

### **Anders Sonnenburg, Xcel Energy**

Anders Sonnenburg holds a Bachelors Degree from the University of Minnesota's Electrical Engineering program. He works for Xcel Energy in their Strategic Technology Department, investigating renewable energy generation, storage and transmission technologies for Xcel. He was involved in the deployment of Xcel Energy's "Smart Grid City" project in Boulder, Colorado.

As an EE student, he helped develop curriculum and projects, as well as source materials required for BRIDGE's outreach work. Mr. Sonnenburg became a member of the National Society of Black Engineers (NSBE) student organization, and continues to volunteer time with the student organizations.

### **Munira Masoud, Xcel Energy**

Munira Masoud is currently pursuing a Masters degree in Electrical Engineering, with emphasis in Power Systems, at the University of Minnesota. She received her Bachelor's Degree in Electrical Engineering at the University of Minnesota in December 2007. She has been a member of the B.R.I.D.G.E (Building Resources and Innovative Designs for Global Energy) Project since it began in 2006. She learned about B.R.I.D.G.E through Professor Imbertson, one of the pioneers of the project, who also serves as her graduate school advisor. Having grown up in a developing country, Tanzania, where the quality of education is still poor and electricity a scarce resource, she immediately related to the project's mission of education and providing sustainable energy resources to villages in underdeveloped parts of the world. Although she has been active in all aspects of the project (design, outreach and implementation), she especially took on the role of Outreach Program Chair, leading weekly sessions held at High Schools in Minneapolis and developing curriculum and small scale projects aimed at introducing engineering concepts to under-represented students in grades 10, 11 and 12. She is also gaining valuable power systems engineering work experience at a local utility company where she has been interning since summer of 2008.

### **Meron Demissie, Mortenson Construction**

Meron Demissie is currently working at Mortenson Construction as a Field Engineer in their Renewable Energy Group after receiving her Bachelor's degree in Electrical Engineering from University of Minnesota in May of 2008. Meron's interest in Wind Energy started following her introduction to the BRIDGE project in 2006 through her active involvement and leadership in the National Society of Black Engineers (NSBE). Meron's main responsibility at work includes overseeing the electrical aspect of the project such as the Underground Collection, Substation, Interconnect & Transmission lines of a Wind Farm Project. She had the opportunity to work on projects ranging from 47 to 83 Turbines in states such as Washington, California, Iowa and Idaho.

# Sustainable Energy: A Bridge between Engineering, Developing Nations and Inner-City Youth

## Abstract

BRIDGE (Building Resources and Innovative Designs for Global Energy) is a project of the National Society of Black Engineers (NSBE). Since 2006 the BRIDGE Project at the University of Minnesota has been impacting students and communities across the state of Minnesota and around the world. Participants create designs for renewable energy systems from scrap, waste, or found materials. They use these designs as an easily understandable foundation for outreach in Minneapolis High Schools, bringing engineering concepts and methods to life for at-risk students. Ultimately, the designs become the core for collaborations in developing nations to implement renewable energy systems in remote communities. The BRIDGE Project employs a holistic approach to learning, using authentic pedagogy and community service to engage students in work that highlights the world-changing potential of engineering and puts students on the front lines of engineering in action. Everyone involved, from the university students of the National Society of Black Engineers, to the minority high school students, to the BRIDGE partners in economically depressed Nicaragua, take equal ownership in the project which, while educational, is ultimately a collaboration of people helping each other to reach a meaningful goal.

## Introduction

The BRIDGE Project started as a class project overseen by Michael Davis, a student from Southern Alabama University, who was participating in a Research Experience for Undergraduates (REU) program at the University of Minnesota. Mr. Davis led a group of incoming minority and female engineering students through the process of designing and building a wind turbine from scratch.

As instructive and interesting as this activity was, the students soon realized the broader value of their work and determined that their work should be brought out of the classroom. Plans were soon made to continue their work as a stand-alone project.

The University of Minnesota chapter of NSBE took the project under its wing and work began to define the scope of the project. The project took shape over a span of several months. After going through many variations, the BRIDGE model took on its final form based on three core areas - Design, Outreach, and Implementation:

**Design** – Along with BRIDGE’s partners in area high schools, and with INATEC and the National Engineering University in Nicaragua, University of Minnesota students develop sustainable renewable energy systems that can be built from scrap materials in remote areas, as well as curriculum for outreach and demonstration.

**Outreach** – BRIDGE members engage in numerous short and long term outreach activities with at-risk high school students across the state of Minnesota to expose high school students to the technical and social aspects of engineering, science, mathematics and culture.

**Implementation** – This area brings the entire effort together as BRIDGE members and partners work together to implement renewable energy systems in remote communities in developing nations.

Plan in hand, the BRIDGE students were ready to get started, but just as an engineer does not work in a vacuum, a project such as the one they proposed could not work in a vacuum either. The project needed partners. This is where Dr. Angela Osuji, and AVODEC came in.

Angela Osuji was a science educator at North Community High School, an inner-city high school in North Minneapolis. With Dr. Osuji's help, BRIDGE began design and outreach activities with several science classes at North Community High School. This collaboration has continued with weekly visits during the program periods for two and one half years.

AVODEC (the Association of Volunteers for the Development of Communities) is an aid organization Jinotega, Nicaragua. With AVODEC's help, BRIDGE began plans to implement their designs in La Hermita, a remote community in Nicaragua that had no electricity or pumped water. There have now been 4 visits to Jinotega and La Hermita to plan, work, and build relationships.

The project has expanded and currently the BRIDGE Project works with four partners in Nicaragua -- AVODEC, INATEC (The National Technical Institute of Nicaragua), (UNI National Engineering University of Nicaragua), and the community of La Hermita.

La Hermita is a village located in Nicaragua, one of the poorest countries in the Western Hemisphere, and is home to roughly 25 families, approximately 120 residents in all. All related to one another in varying degrees, this farming community cultivates crops identical to those grown in pre-Columbian times.

La Hermita is well away from access to the country's electrical grid, though the community is familiar with electrical power. Many of the homes in La Hermita have 12 volt deep-cycle batteries used to power small appliances, and in some cases, DC lighting systems.

These batteries have become a safety requirement, in terms of notification of severe weather systems. This region has repeatedly been severely damaged by tropical storms in the past. Advanced notice by radio weather reports of such emergencies can help these communities prepare for on-coming storms.

The batteries have also brought light to the homes of many students. While at school, or helping the family during the day, most students find time to study only at night. This is otherwise a cumbersome task as the sun rapidly sets behind the mountains to the west.

The community of La Hermita brings together the efforts of all the people associated with BRIDGE project – University of Minnesota students, North High School students and the Nicaraguan community - by providing an opportunity to make a positive impact to those in need

through a knowledge-enhancing and motivating experience for all.

## **The BRIDGE Philosophy**

A brief digression to lay out the philosophy of the BRIGE project can be helpful here. The philosophy has three parts corresponding to the three, intertwined core areas of the project, **design, outreach, and implementation.**

**Design** work in the BRIDGE Project is an application of service learning. Students engaged in service learning develop solutions to real community problems. Their efforts are not purely academic, but their learning outcomes can be more complete and their understanding can be deeper than they might have obtained through purely academic exercises.

Bill Oakes is the director of the service learning program at Purdue University, EPICS (Engineering Projects In Community Service). In the past when Dr. Oakes would review standard student capstone engineering projects, that is non-service learning, he would often encounter projects that didn't work. The students could show that they worked hard on their projects but many aspects of their projects, and much of their understanding of the technologies, were incomplete. Dr. Oakes would contrast these experiences to his experiences reviewing service learning projects. The service learning projects were almost always complete and working, and the students had full and deep understanding of the technologies. The reasons for this difference are likely twofold. First, the students cared deeply about the problems in the service learning projects. Second, the students knew that only a working solution would be of any use to their service learning customer, the community in need. This is quite a change from the case where the student's customer is a professor, where the professor can still determine the student's level of understanding from a non-working project. Under the service learning model, the students can't stop at "good enough to show understanding". They need to continue to work on the problem until it reaches a final working solution.

**Outreach** efforts are based on meaningful learning. Students are brought in as active partners in solving renewable energy problems for remote communities. Dr. Osuji describes this as "authentic pedagogy". The high school students are full partners in the BRIDGE mission with the expectation that they will positively impact people and communities far removed from their own experiences, giving them a link to people and communities outside of their neighborhoods.

**Implementation** is guided by the principle that ultimately the work is in the hands of the people of the communities in which the project is placed. Implementations are based on locally sourced materials. Preferably, scrap or found materials. The guiding principle is that the BRIDGE project does not want to import its own culture or ethos to a developing region. The product, renewable energy systems, should become extensions of the community's existing culture.

This philosophy can be stated (only slightly tongue in cheek): Thou shalt not drop shiny things in the hills. There are numerous examples of aid groups who have installed water systems in remote areas only for the systems to break down in short order with no one around to maintain them. This philosophy recognizes that members of communities all over the world are perfectly capable of producing all sorts of machinery and systems, and often better than their benefactors

from developed countries could.

If installed by the community itself, the systems and the technologies can become a part of their own story and children growing up in these remote areas would see the world open up to them.

### Activities

The following table illustrates the various activities that BRIDGE members engage in.

<b>DESIGN</b>	
Table Top Wind Turbine	A mini wind turbine made from found material such as cardboards and old floppy drives, used as a simple basis for teaching high school students the workings of a large scale wind turbine.
Anemometer	An anemometer is a device new to remote villages. High school students collaborate with BRIDGE members to design simple anemometers from readily available material so communities like La Hermita can have access to it.
Beaufort Wind Speed Scale	Different geographical areas have different environmental conditions. Rural communities like La Hermita can produce their own standardized weather scale based on visual clues in their environment, similar to a Beaufort Wind Speed Scale.
<b>OUTREACH</b>	
North Community High School	Once a week, in Dr. Osuji’s science classroom, high school students get exposed to science, engineering, and technology through projects that provide them with opportunities to share ideas, especially on energy, that can help deprived communities abroad obtain basic necessities such as water.
University of Minnesota Visits	Faculty members and graduate students in various departments at the Institute of Technology have opened doors to their research facilities for the high school students to explore and hopefully gain interest in pursuing STEM fields.
University on the Prairie	BRIDGE members participate in this summer workshop in rural Minnesota and expose other

	students to opportunities in science by providing hands-on projects related to energy.
White Earth Indian Reservation	BRIDGE members work with students on the White Earth Indian Reservation in a summer program covering much of the energy, and engineering efforts of the BRIDGE Project.
<b>IMPLEMENTATION</b>	
La Hermita, Nicaragua	Trips to La Hermita, Nicaragua allow members to understand the community's needs, study the environment's suitability for wind energy, make essential measurements & educate the community about the technology, leading up to the actual wind turbine implementation.

On March 17<sup>th</sup> 2008, BRIDGE's outreach team arranged a field trip for 35 high school students from North High to visit various laboratories in the STEM areas at the University of Minnesota. This was an eye-opening experience for many of the students involved.

Based on results of a questionnaire that was completed after their tour; 68% of the students showed positive interest in thinking about a career in STEM, 86% of the students showed positive interest in returning to campus several times per year to meet more Institute of Technology college students as mentees.

In March of 2009, 45 students from North High attended the Institute of Technology Campus Tour and in March of 2010, 83 students attended from Anwatin Middle School. We believe that these campus visits play an integral role in influencing students to consider STEM areas by giving them an opportunity to walk in the shoes of a regular college student in the STEM field. This helps to mitigate the misconception, common among these students in particular, that one needs to be extremely gifted in order to succeed in the STEM area.

On the first visit to Nicaragua, an anemometer was brought to the community of La Hermita. After a brief training on the functionality of the anemometer, one of the young students of the community took the due diligence to record daily wind-speed readings and to make sure that the anemometer was functioning properly. On the following trip to Nicaragua, BRIDGE members observed that more and more members of the community were showing interest in the wind turbine system and became increasingly engaged in the project.

BRIDGE members, in collaboration with students from INATEC (Nicaragua National Institute of Technology) and Dr. Jeronimo Zeas from UNI (Nicaragua University of Engineering), concentrated on building and balancing the blades made from PVC pipes. With every visit, BRIDGE's relationships with the partners and the community are strengthened. By focusing on one aspect of the wind turbine system at a time, a thorough and responsible transfer of usable knowledge is possible.

## A Fluid Structure

The BRIDGE Project has evolved since its conception. New partners are continually coming on board and new connections and working relationships are developed. This is in keeping with the central idea of BRIDGE, that all participants are partners, and all partners have a voice in the future directions of BRIDGE.

The following table highlights the range of these partnerships.

<b>PARTNER</b>	<b>ACTIVITIES</b>
North Community High School	Ongoing collaboration and exchange of ideas between students at North High School and BRIDGE members is key to accomplishing the group's mission
AVODEC	BRIDGE began working with AVODEC in January 2006, after being introduced by another humanitarian group with beginnings at the University of Minnesota, Bright New Ideas. AVODEC has been a critical partner for BRIDGE, since they are intimately aware of the issues, concerns and needs of the surrounding communities. They serve as a vital link between the partners and community members.
UNI – National Engineering University of Nicaragua	The Electrical and Computer Engineering Department of the University of Minnesota recently signed a memorandum of agreement to promising to pursue mutual projects with UNI. Professor Zeas of UNI is currently designing wind turbine/battery systems for an isolated community near Managua, Nicaragua.
INATEC	Francisco Gonzales, Director of Jinotega's INATEC Campus welcomes BRIDGE and National Engineering University of Nicaragua team members to his campus. He works alongside his staff and students on the design, construction and testing of the wind turbine systems. INATEC has graciously provided a workspace, tools and a convenient test site for this project. Their efforts and resources are imperative to success.
M. A. MORTENSON	M A Mortenson has been an invaluable resource supporting BRIDGE financially as well as providing technical expertise

CUMMINS POWER GENERATION	Cummins has been very supportive, providing BRIDGE with essential resources such as construction & teaching materials, financial assistance and technical expertise
LA HERMITA, NICARAGUA	BRIDGE is working with the community of La Hermita to construct a wind energy system for battery charging. Previously, BRIDGE helped the community to install a hand-cranked rope pump for the community well.



## **Moving Forward**

Given that the BRIDGE project is in its fourth year, great progress has been made but there is always room for growth. The design team continues to put effort into coming up with new and more efficient designs that can be incorporated in the high school science curriculum and can be implemented in remote villages around the world.

The outreach team continues to revise curriculum as new developments arise. Plans are at hand to expand the program to other high schools in the Twin Cities. As we expand to more high schools we are able to influence more students to pursue careers in STEM fields.

The implementation team has made the trips to Nicaragua possible through careful planning, research and fundraising. A few members were able to go to Nicaragua in August 2010 to begin the final phases of the wind turbine implementation. A trip to Nicaragua is planned for June 2010 to complete setting up the wind turbine to provide the community of La Hermita with reliable and sustainable energy. This trip may also be an opportunity for some of the North High School students to witness the impact their work has made to other communities.

## **Acknowledgments**

The partners that have supported the BRIDGE project are greatly appreciated. We hope to continue collaborating with our current supporters and expand partnership with other organizations here and abroad.