Engineers Without Borders: Solar Recharge Project in Burkina Faso

Entry for NCEES Engineering Award for Connecting Professional Practice and Education

Abstract

Engineers Without Borders (EWB) is an internationally recognized volunteer organization whose goal is to partner with developing communities abroad to collaboratively design and build small-scale sustainable engineering projects to benefit those in need. Rapidly growing in size from when it was started less than 10 years ago, EWB has expanded to over 12,000 members, working to address the needs of communities in over 45 different countries across the world. In 2004, students and faculty from our university's engineering school joined the then-young organization with the establishment of our own chapter. As a new chapter, we first took part in a joint effort among several universities to design and build an orphanage for a small village in Samli, Thailand. Now, six years later, the combined efforts of hundreds of dedicated engineering and non-engineering students, faculty, and professionals have enabled the completion of 14 distinct projects in 7 different communities abroad. In addition we have also expanded our focus to include similar small-scale engineering projects that address the needs of communities surrounding our university. Today our chapter continues to pursue up to four separate projects at a time – providing over 100 students each year with the invaluable experience of designing solutions to real-world problems under the close guidance of professional engineers and university faculty. Many of these students go on to realize the impact of a designed solution through its implementation as a sustainable improvement to the quality of life in the communities abroad.

Thus far our chapter of EWB has worked in Ecuador, Brazil, Thailand, Peru, Ethiopia, and Burkina Faso – enabling over 150 students, 20 professional engineers, and 8 faculty from a variety of disciplines to travel to these countries for the implementation of their designs. Many more are able to participate in the vitally important research and design work, and the approval process that closely parallels the process a professional engineering team would go through in an engineering design firm. Unlike taking a course in sustainable development where students may only have time to conceptualize an engineering solution, the students in this program come away from a project having gained exposure to all aspects of a real engineering project. With a multidisciplinary team of students, faculty, and professionals, they participate in a detailed engineering design, drafting and approval process, create a schedule and budget, and procure materials and equipment for use on the construction of the project, then go on to actually build it. Through this organization, students are given the opportunity to apply the knowledge and skills they are learning in their university education to a meaningful cause. Students dedicate their time without pay or school credit – but with a sense of personal accomplishment and with the understanding that through good work ethic and acute attention to detail they can collaboratively make a positive difference in the lives of others.

The following submission includes a general introduction to the organization and our motivation for this application, this program's objectives and structure, the role of the students involved, and the process they follow to complete a project from assessment to implementation. It also discusses the faculty and professional engineers on the projects and their role in collaborating with the student teams. Thirdly, it includes the impact that these projects have on the students in preparing them for their future careers. The final section provides a detailed description of one of the projects completed by our chapter called the Burkina Faso Solar Recharge Project – a project completed in January of 2009 that brought off-grid electrification to 22 villages around Dissin, Burkina Faso – and how this project, like the other projects, meets the criteria for the NCEES award.

Introduction and Motivation:
The student members of our organization are inspired by the work they do to address fundamental human needs in communities of developing countries. Each student that returns from a project implementation trip with EWB devotes an abundance of time and energy toward making more opportunities for others to take part in this same line of work. The students that have worked on this application are driven, above all else, to impress upon other universities and interested parties the tremendous degree to which working in the learning-intensive, fast-paced environment of EWB can be motivating and inspirational for all who choose to participate - students, engineering professionals and faculty included.

When students join the organization, they join teams of their peers that have identified *real engineering problems.* Together, they work with faculty and professional engineers to develop the most appropriate solutions to address these problems. They are given the opportunity to research the needs of the client community, to collaboratively design unique solutions, to defend their design decisions in front of professional engineers, and, finally, to personally implement their approved designs. This *complete engineering project process,* from start to finish, is something relatively few students are intimately exposed to in their academic careers, and it is something we hope to show the value of in this application. We collectively feel that being a part of this organization, above all other activities, has taught us the most about the importance of professionalism, knowledge, leadership, teamwork, and communication. Through our experiences on project teams, we have seen firsthand the results of strong organization and leadership, and we have learned an ethical model for engineering that we can use and improve upon in our future academic and professional careers.

We realize that we are not the only university to have such a program under the same national organization. However, rather than allowing this be a deterrent to applying, we feel that it is further motivation to show other universities without such a program how beneficial an organization of this nature can be. We cannot and do not claim to be the "best" – every EWB chapter has a slightly different structure that works best for its members. However, we feel that by being one of the senior chapters of the organization we benefit from years of project experience, including successes and failures, and have grown stronger as a result. We hope that in applying for this award, we can represent our university and its engineering department, our parent organization, and our students. We hope to clearly show how the unique partnership between these three parties can create a powerful medium for students to learn real engineering skills in a motivational, rewarding, and constructive manner.

Organization Description

Objectives: Meeting the needs of the disadvantaged while raising strong, knowledgeable future engineers
Our chapter of EWB seeks to accomplish two main objectives, aiming to benefit both the greater community beyond the borders of our university, and the students that choose to dedicate their time within the organization.

The first objective is to *provide the means to solve community-identified problems for the benefit of those in great need* of the essential elements for a healthy life. The partnering communities participate in all aspects of EWB projects, from identification of the need to be met to the implementation of the solution. They additionally benefit from the engineering knowledge and sustainable technology that the student teams are able to share. This process of joint

collaboration enables community members to continue the process of *improvement of their health and welfare* in the future, after completion of the project's specific goals. With this there is also the added benefit that the student participants come away with a *raised awareness of the world issues* that exist, and an understanding of how these issues can be resolved.

The second is to *promote the growth and improvement of aspiring engineers* for their future careers, which is fostered by providing opportunities to practice learned engineering skills. The engineering curriculum focuses on courses to develop the theories and concepts needed for a strong fundamental knowledge in this discipline. This education is essential to have before beginning an engineering career, but minimal time is available to apply this knowledge to a hands-on, "real" world experience. EWB provides students the freedom to take charge of an engineering project with their peers and with licensed professionals, and to motivate themselves to see a real project through to completion. Students grow their knowledge and engineering skills, learning from the *8+ dedicated faculty from 3 different disciplines and 20+ professional engineers from 8 different companies* that have actively participated on our EWB projects. In addition we strive to organize professional-taught seminars, trainings, and conferences on topics such as project management, leadership, health and safety, financial, and sustainable development to students. We also provide opportunities to improve the students' communication skills by sharing what they have learned with others in presentations, student panels, and high school educational programs.

Organization and Project Structure: The role of students, faculty and professionals

The majority of the time students spend within EWB is working in their project teams of 15-40 students, under the leadership of 1-2 project leaders. Because of the broad scope of each project and the large number of students involved, the projects are also broken down into subgroups, each led by a subgroup leader. Each subgroup is in charge of a specific aspect of the project, allowing them to focus more on specific goals. This general structure, we have found, is efficient and gives more students the opportunity to be in a leadership role, and fosters potential leaders for the future. At least one faculty member and one professional engineer also participate on each project, providing guidance, engineering design help, and recommendations throughout the project process. EWB-USA, our parent organization, recommends that the projects each have at least one *licensed professional* working with the students, though additional professional guidance is always encouraged. The nearby professional chapter of EWB readily and willingly provides support for our projects seeing as much benefit in participating in this nature of projects as the students do. As one of the professional engineers explained in an interview, "I have gotten the opportunity to do something I would never have done otherwise... I have not regretted it one bit." A student on the same project agrees that there are many benefits of this collaboration - "having professionals working on [our] project was a key factor in the project's quality and success. It was important to have someone experienced to answer questions... and show us the ropes."

All of the 3-4 projects per year within our chapter run in parallel, governed by a student committee of 8 student officers and the project leaders from each team. The elected officers work to ensure that the organization is run smoothly — approving and monitoring project progress, securing funding for projects, providing oversight of project spending, and conducting outreach to the community, engineering professionals and the university student body. Compared to a university course which may only span a semester or a year, what is unique about this opportunity is that students can learn and improve through not just a semester or year, but their entire college career. While there is much benefit that is gained from even participating on one project for a year, for those who remain involved for longer, they have the opportunity to run the organization or a project, and be exposed to

not just one but several engineering problems and gain knowledge and skills in multiple areas of engineering.

Project Development: The complete project process from assessment to implementation
In order to ensure consistent quality of the projects that are completed within EWB, each project goes through a standardized process of development typically spanning 1 to 2 years in total. In describing this process we hope to both better characterize the organization's project process and explain the experience students, professionals, and faculty members take away from the completion of a project.

A project first develops after a contact from a developing community approaches a student or faculty member with a basic infrastructure problem. If the chapter agrees to develop the project, a proposal outlining the goals and the scope of the project is submitted to EWB-USA. If approved, an assessment team is formed – typically comprised of two students, a faculty advisor, and an engineering professional with expertise relevant to the proposed project. The team travels to the project location for approximately two weeks to meet with local contacts, identify and characterize the problem facing the community, collect data needed for future design work, and form strong ties with the local community.

If the assessment results support the continuation of the project, the assessment team members are expanded to a team of students and professional advisors that work together to design a sustainable engineering solution. Design work usually takes place over the two academic semesters after the assessment trip and is completed entirely by students and advisors on a volunteer basis. As the design phase of a project develops, often more information may need to be collected at the location of the project site, and further community input may be helpful in selecting design alternatives. In some instances, a team may travel again to the community in between the initial trip and the implementation trip to collect additional information to ensure the adequacy of the team's design solution.

Before the students' designed solution can be implemented, it must first obtain approval by a group of engineering professionals with no connections to the project, known as the Technical Advisory Committee (TAC) from EWB-USA. The design solution, implementation procedure, safety protocols, and trip logistics are submitted to the committee for review and are followed by a conference call to discuss the proposed implementation trip. If the professional committee agrees that the project meets the community's needs in a safe and sustainable approach, an implementation team is approved to travel. The faculty advisor, engineering professional(s), and a larger team of students return to the community to complete the implementation. The team spends 3-4 weeks living with the community and working alongside them to build the solution they have designed. Time is also dedicated to educating the community on the project and how to maintain it, and empowering them with the knowledge to take ownership of the project's design, and replicate the project in the future.

After successful completion of one project, additional projects are subsequently assessed, developed, and implemented within the same community to continue a partnership that will last five or more years. As with all other chapters of EWB, this thorough process that all project teams complete gives all students and advisors the fulfilling experience of seeing the beneficial results of their hard work. The students better understand all aspects of a real engineering design/build project and gain an appreciation of the effort it takes for a team to complete even a small scale project.

Beginning in 2007, our EWB student chapter has worked with the community of Dissin, Burkina Faso to help address part of their water, lighting, and electricity needs. The following discussion will focus on one of the projects completed in the community that brought solar-powered battery recharging stations to 22 villages. It discusses the background on the problem students identified on their assessment trip, the final design that was implemented and how this meets the goals of the NCEES award criteria. This project is used to serve as an example of the other, similarly structured projects that our chapter of EWB has completed.

Example EWB Project: Burkina Faso Recharge

Background

Burkina Faso, the landlocked neighbor of Ghana in West Africa, is one of the poorest countries in the world. With more than 80% of its population relying on subsistence agriculture, and a literacy rate of 30% among men and 9% among women, prospects for development are dim in the absence of sustained assistance to build its basic infrastructure and education system. Efforts are being made to improve literacy but because a majority of the population works during daylight hours, the only times that can be dedicated to learning are after dark, using lights powered by car batteries that must be regularly recharged. Dissin is a small region located in the southwestern part of Burkina Faso made up of 24 village communities spread throughout a 15 km radius. Less than a handful of cars exist in the region at any given time, thus in order to reach a location where car batteries can be recharged, the villagers must travel long distances on foot or bicycle to reach an unreliable and expensive source of electrical power. An EWB assessment team that traveled to Dissin in 2008 found that the 6,000+ villagers who live outside the town center have significant difficulty accessing electricity.

Engineering the Solution: Solar Powered Battery Recharging

To address this need for expanded access to electricity, students within EWB, under the guidance of professionals and university faculty, designed and implemented a sustainable off-grid electrification solution in these rural villages of Dissin. A network of 22 solar-powered battery recharging stations was chosen as a way to bring more accessible in-home electrification to the villagers. The student-designed solution enables villagers to manage their own source of energy and reduce their dependence on costly kerosene for dimly lit lanterns.

The battery recharging systems were designed with the following objectives in mind:

- Use of solar panels and charge controllers that meet the recharging needs of the villagers
- Design of a mounting system for the panels that can be adapted to fit the roof of most buildings in the region
- Creation of a business plan to sustain and maintain the systems, and to empower villagers to start small businesses and develop their local economy

Students spent the fall 2008 semester working with professors and professionals, prototyping and finalizing a design of the recharging station, as well as developing solar demonstration and training materials to educate the villagers. Ease of installation and local availability of materials were especially considered to design a system that would be conducive to maintenance and expansion by even the least experienced in the community. The electrical components of the design were tailored to be robust and safe – and like the rest of the system – were selected with consideration of their in-country availability in order to facilitate the maintenance and expansion of the installed systems. The mounting system had to be engineered to adapt to various types of corrugated tin roofing characteristic of the buildings in Dissin, challenging the team to design a simple yet robust system

that would meet the needs of a variety of roofs. A student-drawn computer aided rendition of the design is shown in Figure 1.

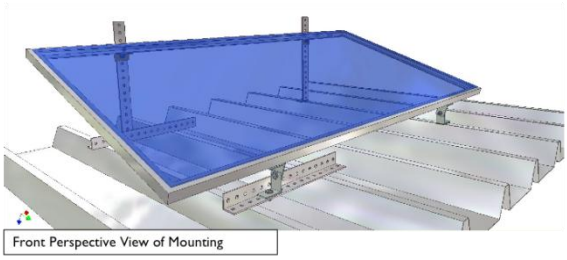

Figure 1. Computer aided rendition of solar panel mounting system

The business model created for managing the solar powered battery recharge network was developed with the local community. The "Structure Centrale" is the main operating body, which provides basic services to local recharging station operators in exchange for a monthly fee. Local operators charge customers' batteries for a fee. The local operators pay a flat monthly fee to the Structure Centrale and keep a small portion of earnings as profit. The revenues received by the Structure Centrale are reinvested in new local recharging stations. This is diagrammed in Figure 2.

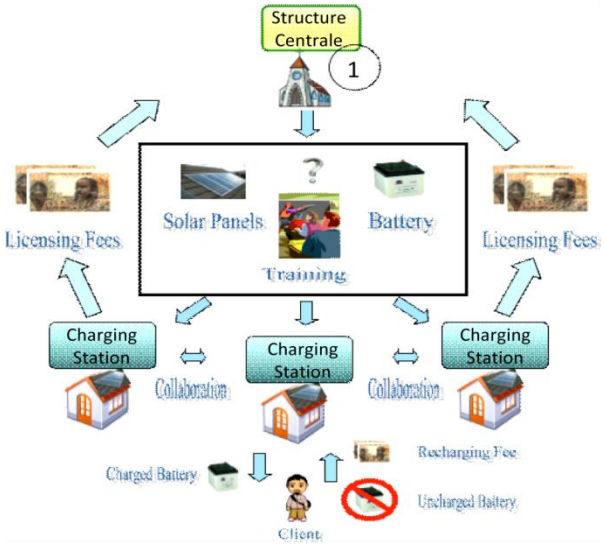

Figure 2. Outline of cooperative business model

This phase of the Burkina Faso project within EWB was successfully completed in January of 2009. Our chapter of EWB continues to work with the village of Dissin to address other issues such as water access, sanitation, and further electrification. This phase of the Burkina Faso project, like the many other projects completed each year, is a good example of how beneficial a successful effort a partnership between students, faculty, professional engineers and a community can be for all who are involved. The following paragraphs specifically address the criteria of this award.

Collaboration of Faculty, Students and Professional Engineers

During the assessment and implementation of the project, students, faculty, and professional engineers worked side-by-side to evaluate and address the needs of the community. During the design and prototyping stage of the project, students took the lead and had the freedom to showcase their own ideas, which were supported by the faculty and professionals working on the project.

Benefit to Health, Safety and Welfare of the Public
The implementation of the solar powered battery recharge network has enabled easier access to electricity for the villagers for a variety of uses. The primary benefit is for use in powering lighting at night, which provides a way for villagers to improve their reading and writing skills during non-daylight hours. With the implementation of the business plan created, the villagers will keep the profits from the fee charged within Dissin, rather than paying outside sources for this service. The fees collect over time, allowing for funding for further expansion of access to this service to the villagers and increase profits for the village owners. This business model created with the community is aimed at empowering villagers to have more control over their money and to start more small businesses with the same model. Additionally, electronic communication devices such as phones, radios and TVs can be used for greater access to the world beyond Dissin.

Impact of Raising Social Consciousness
The students who participated in this project were exposed to the plight of disadvantaged communities. In addition, students saw the need for considering sustainability in engineering designs, especially in remote areas. Additionally because this project is a part of the greater EWB organization, students involved in this project have the opportunity to participate in other projects of similar nature in their remaining years at the university. This provides exposure to a variety of very common issues that developing countries continue to struggle with today such as access to safe drinking water, proper wastewater treatment and sustainable construction.

Impact of Partnering Teaching and Professional Practice
As with any project, the professional engineer and university professors, along with the students, are given the opportunity to participate in the design and implementation of a project that is not typical of the everyday workplace. They are given the chance to mentor young students who will be future engineers, pass on their knowledge and expertise in the field and see the students grow throughout the process. In this project the professional was able to pass on his knowledge of efficient capture of solar power and utilization of charge controllers to both the students and the villagers, and he was able to have the fulfilling experience of seeing his efforts in action as the villagers begin to utilize the 22 installed systems.

Multidiscipline and/or allied professional participation
Professionals offered technical consulting and help for evaluating engineering designs and worked closely with students in the implementation stage of the project to help them look at all phases of the project from a professional's perspective. The business students who participated in this project helped the engineering students better understand the development of the business plan for the community. Likewise, the engineering students introduced the business students to the technical design details of the project. This combination of disciplines on one team facilitated learning outside of the students' general focus in their college studies, widening their perspective and challenged them to look at the project from different angles.

Knowledge or Skills Gained
Students experienced the process of hands-on engineering. As with most hands-on engineering projects, students learn to work effectively as a team, to evaluate the viability of engineering ideas, seek approval of these ideas and put them into action. The unique part of this program, we feel, lies in the opportunity for students to, after participating in this one project, continue to work on other projects within the same organization, but with a different problem to solve. Of those who traveled to

Dissin, the project leader of the is now a EWB-USA State Representative, one student is the President of the local Professional Chapter of EWB, three are project leaders or executive board members of the student chapter, and the remaining three are now working on other EWB projects. They continue to expand their knowledge and skills in the engineering field, improve their problem solving skills, and learn how to be better, more efficient leaders and communicators.

Viability of Technology Used

In this project students gained a better understand solar power systems, a design element that is becoming more common in modern building design and construction today. Additionally, students learned how to use modern drawing software to create design drawings of the chosen design solution. In this age of sustainable and green building, this simply designed solar-powered recharging system, though not as complicated as the sophisticated systems used in the US, is useful for the students to understand in both design and construction practice for their future careers.

Conclusion

We feel that this organization and the projects within it are of great benefit to all who are involved. The professional engineers, students and faculty who participate are brought together with a common goal of helping others in need. Being a responsible, informed engineer is something all students in the engineering discipline strive to achieve both in their college careers and in the future. It is our hope that programs such as this will continue to grow in number and support for the benefit of all in the future.