The Role of International Projects in Engineering Education: Biofuel Electrification in Orissa, India

M. L. Somers, T. P. Walsh, B. P. Barnes, S. N. Bogle, S. Poust, B. M. Haman, and J. M. Appleford
Engineers Without Borders, University of Illinois at Urbana Champaign,1308 West Green Street 110c, Urbana, IL 61801
mlsomers@uiuc.edu, tpwalsh@uiuc.edu, bpbarnes@uiuc.edu, bogle@uiuc.edu,
poust@uiuc.edu, bhaman@uiuc.edu, applefor@uiuc.edu

Abstract **- Engineers Without Borders (EWB) is a nonprofit organization based in the United States that provides engineering students with the opportunity to gain practical experience working on community-initiated projects internationally. Coordinating design and implementation with partners in the US and abroad enables students to develop important problem-solving skills, while exposing them to relevant global challenges and the complex environmental, economic, social, and political factors associated with achieving appropriate solutions. Students from the EWB chapter at the University of Illinois at Urbana-Champaign (UIUC) were presented with the opportunity to work with a national Indian non-governemental organization (NGO), Association for India's Development (AID), and a local NGO, Ghana Chetana, to develop a source of electricity in rural villages in the state of Orissa. The success that EWB-UIUC has experienced in developing a modified diesel generator to run on locally produced, straight vegetable oil has the potential for widespread application. The generator set powers agricultural equipment, as well as a community-instituted electrical grid. The students spent several weeks in-country to assess options for power supplies, followed by a year of design, two months on-site to implement the system, and two days on-site for post-assessment. The team is continuing research to disseminate the technology.**

Index Terms – Biodiesel alternatives, biofuels, humanitarian engineering, rural electrification, sustainable development

INTRODUCTION

Engineers Without Borders at the University of Illinois employs a model of independent volunteer student projects as a form of alternative and supplementary education. While efforts are advised in principle by a faculty member, the content, scope, design, and implementation are entirely directed and carried out by students, who recruit their peers as necessary to complete objectives communicated by a community in the developing world. Students gain important interdisciplinary, technical, and cultural experience, which are examined in this paper. This experience develops technically competent, globally aware engineers who are better able to address the evolving objectives of their disciplines.

THE PROJECT-BASED MODEL

There are four main steps in any EWB development project: (i) site assessment, (ii) design, (iii) implementation, and (iv) post-assessment. Depending on the complexity of the project, multiple iterations of these phases may take place.

The national office of EWB aggregates requests from communities in the developing world, which usually are related through one or more local NGOs. Each request is matched with a student chapter of engineers which has applied for a project. The student chapter consists mainly of undergraduate students within engineering disciplines, however graduate students and non-engineers may also form part of the project teams. After the student chapter performs initial research, establishes communication with partners, and raises funding, a site-assessment team travels to the community abroad, usually during the summer or winter months when university classes are not in session. The team gathers technical information to be used for design work and familiarizes itself with the community abroad.

After returning to its home campus, the student chapter sets to work on designing a solution for the community's request. The design phase usually takes place over a span of half a year or more. The complete plan of action is submitted to a professional engineer and then to the national EWB office for approval.

Student chapters must concurrently raise implementation funding, which is often derived from grants, awards, and university sponsorship. The project implementation can then begin, usually with a team of students travelling to the community abroad to physically install equipment. In some cases, a professional adviser accompanies the team. Implementation trips are usually taken over the summer months to allow students ample time for local materials acquisition and construction.

After implementation, the student chapter maintains communication with local NGO partners abroad. Ideally, an on-site study is carried out after a year to analyze the successes and faults of the implementation.

INTERDISCIPLINARY DESIGN & LEARNING

Interdisciplinary collaboration has been recognized as an integral part of education for sustainability. EWB projects necessitate the contribution of diverse knowledge and expertise throughout the phased project-based model. Interest in the outcome of the project for communities, research, and society also draws a variety of participants who are able to share their personal skills and abilities.

The Orissa Biofuel Electrification Project brought together students in agricultural engineering, civil engineering, mechanical engineering, engineering physics, and materials science engineering. The unification of this diverse group around a common goal was an important experience rarely available to undergraduate students. To some extent, specific aspects of the design were guided by individuals most knowledgeable about the field: agricultural engineers focused on the availability and content of oil seeds; mechanical engineers provided knowledge about options for using the oil within various types of engines, as well as potential problems using vegetable oils; civil engineers provided information about structural issues with the building used to house the project components. But in general, the design was managed by students working outside of their academic foci, which lead to increased interdisciplinary exchange. Students following their focused academic track were exposed to concepts totally outside their field of study.

A CONTEXT FOR TECHNICAL DEVELOPMENT

The international project model yields students with technical proficiency in a way that academic coursework cannot in two primary ways. First, a real-world project necessitates making reasonable assumptions, a skill often required in engineering that is difficult to teach in a class setting. The biofuel project team initially set out to gather all necessary data, but quickly faced the challenge of substituting non-ideal data or designing without certain information. Assessing whether waste heat could effectively preheat the vegetable oil for injection into the cylinder was difficult. The viscosity, flash point and other properties of the vegetable oils was not available and had to be assumed. As such, the team was forced to design a system using an electrical heater and justify this decision with its relatively low loss in total system efficiency. The international and rural nature of this type of project places yet more demands on the students' confidence and intuition because of the frequent lack of data.

A second source of educational value attributable to this model is its results-driven nature. A project that is purely hypothetical can never achieve the same level of realism and demand on the student as a project for which the only answer is an effective solution, both designed and implemented. Engineering challenges often occur after design and during implementation, and this team learned significantly from these experiences. In one instance, the construction location had to be changed on short notice, leaving only a patch of land that flooded annually. The resulting design challenge required scheduling flexibility and consultation of experts. In fact, many if not most of the design elements of the project were altered when the local availability of materials and expertise was discovered. If the design had been concluded before implementation, as is often the case in academic settings, many such engineering challenges would have gone unseen or the results would have been infeasible for the community.

CASE STUDY: BIOFUEL ELECTRIFICATION

Working with Partners: Project Initiation

In 2002, the Orissa chapter of Association for India's Development (AID), in cooperation with a local NGO, Gana Chetana, proposed an electrification project for one of three villages in the Keonjhar district of Orissa, India. Gana Chetana works on the ground with over 20 villages in the district, encouraging small income-generating projects through women's self-help groups. Due to absence or failure of electrical grids in the region, many communities use diesel engines to power agricultural processing equipment. AID wondered whether local forests containing a variety of oilseed-bearing trees could support vegetable-oil-based fuels. Although this process would be labor-intensive, the production of local fuels could serve as a means to overcome the difficulty and cost of acquiring diesel fuel, as well as a method to support income generation for the landless tribal communities in the area. Additionally, the project would encourage reforestation and community organization. The newly-founded EWB-UIUC chapter accepted the challenge in January of 2003 as the group's first international project.

Gaining Experience In India: Site Assessment

Pre-site-assessment preparation included familiarizing all of the students volunteering to work on the project with the applicable technologies and with the communities of interest in India. The team gathered as much information as possible from contacts at AID prior to travel. The site assessment survey addressed questions which necessitated research on-site, ranging from which land was available for the generator, to what types of generators were available, to what kind of organization the village envisioned for an oversight committee. The site assessment team consisted of five students from UIUC, a member of AID, three students from the Kalinga Institute for Industrial Technology (who served as translators), Gana Chetana, and a research scientist from Orissa University of Agriculture and Technology (OUAT). The group visited India for ten days, four of which were spent touring the three potential host villages interested in the project. During the visit, community interviews were conducted, oilseed trees were surveyed, and possible sites for a generator building were established. From this site assessment, the team chose the village of Badakamandara as the host community for the experimental implementation. Badakamandara had the largest amount of organized self-help groups, the closest proximity to tribal villages, and the greatest capacity for supporting an electrification project.

Student-Group-Based Design & Implementation Process

The design phase began the following academic year. After considering the available options for electricity generation, including solar and wind power, students decided that AID's recommendation to make use of locally available oil seeds for use in a diesel generator would be the most economical and sustainable for the village.

Many schemes make use of chemical processes to transform vegetable oil into biodiesel. These processes are complicated and difficult to implement in a village setting. Instead of modifying the oil, the team set out to modify an existing Indian diesel engine to accept straight, filtered vegetable oil. Using this simpler form of biofuel leaves out the difficult chemical reactions and harmful substances involved in refining biodiesel.

The complete system design installed in the village included an Indian diesel generator modified to run on locally produced, straight vegetable oil, and equipment to extract the vegetable oil (a solar dryer, decorticator and an oil press) housed in separate rooms of a lighted brick building. The generator set powers agricultural equipment, which was also installed, and had the capacity to power a village electricity grid, the construction of which was left to the community. Implementation took place from May to July of 2004.

The great majority of the equipment was procured locally and built or modified on site as necessary. The only major components brought from the U.S. were some engine-modification parts, including an in-line oil pre-heater. A similar device could have built in India, but time constraints made it necessary to fabricate these more complex components before arrival.

Non-technical Challenges

Since the design process was completed from overseas, efficiency depended on acquiring accurate information from contacts in India via email and telephone conversations. This pre-implementation communication was a persistent difficulty. When working in the village itself, communication problems continued, as unbiased and accurate translation was difficult to acquire. Explaining the details of the project to the local community proved to be of primary importance.

Over the course of implementation, the team overcame many challenges. The original construction area chosen during the site assessment was not community-owned land, as the team had originally been informed. This resulted in local political disagreements, which were eventually settled, yielding an often-flooded rice paddy as the location for the project site. The housing structure had to be redesigned to withstand seasonal flooding during monsoon season. This aspect of the design was tested while the students were still on site as monsoon reached full force. The monsoon proved to be an additional challenge, flooding the local dirt roads, making access to the nearest town where supplies, tools, and communication availability were acquired difficult or impossible.

Another cultural challenge was determining how to set up the management of the project so that all members of the village benefited equitably. The group had to request the presence of the female leaders of the community at planning meeting; they were otherwise not invited as the meetings were held late in the evening. The group also had to adjust to work style and pace of the local community in-order to receive the necessary sweat equity from the community.

In addition to constructing a brick building and installing a large amount of specially-designed equipment, the students were charged with teaching members of the community how to use the equipment and with outlining the necessary procedures for oversight and maintenance to ensure long-term viability of the project. The students honed their engineering skills while developing their ability to communicate technical knowledge to lay people and to set up a sustainable community-run business.

Follow-up: Post-Assessment Outcomes

A post-implementation assessment was completed in December 2006. The village had added electric power lines in the interim so that 50–60 of the homes are now electrified with 10-watt compact fluorescent bulbs. In exchange for electrical service, each family donates five rupees and 1.5 liters of vegetable oil per month, per bulb. Families derive the vegetable oil from remarkably diverse sources. The seeds used are often from kusama or tulo trees, and depending on the family's abilities and preferences, the oil may be purchased from other families, purchased from local women's groups, pressed in a nearby town, or even produced entirely in the home using primitive methods. The lights now in use replace and supplement the ubiquitous kerosene lamps, which provide drastically less light and emit harmful fumes into the home. Three committees were set-up by the village to oversee the project: A maintenance committee manages financial accounts and repair. A vigilance committee ensures that homes only use the number of bulbs they pay for. And an oil committee assigns the day on which each family will contribute their share of fuel. The community uses a rotating schedule for oil contribution, so that it can continually supply the generator with fuel to run for three to five hours per night. The committees currently maintain a bank account with substantial cash savings for maintenance.

The project is overall an ecologically and economically appropriate one for the community. The village's demonstrated commitment to the project has left the team confident that the project will be sustained in the long-term, giving the local population the capacity to continue improving their quality of life as income-generating projects take hold.

CONCLUSIONS

The EWB phased project-based model succeeded here in benefiting both a community in the developing world and the community of engineers at the University of Illinois. There is a potential for extension of the technology to thousands of rural villages across India. The project was fully managed and executed by students, and provided unique learning opportunities due to interdisciplinary design, cultural exchange, and practical problem solving. Traditional models for such experiences, such as senior capstone design, internships, or academic study abroad, do not generally provide for the creativity, innovation, or cultural immersion that working with an international client provided. Research on this educational model is ongoing, as it has the potential to provide relevant learning experiences for students, significant opportunities for research, and extension of basic amenities throughout the developing world. The education of students via similar projects has the potential to develop relevant human resources with the broader perspectives and skill sets necessary to develop globally aware citizens and, ultimately, more sustainable societies.