International Service Learning Projects for Electrical and Computer Engineering Students

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Abstract

Students in various engineering disciplines have been involved in international service learning activities through, for example, student chapters of Engineers without Borders. Most of these projects tend to be either civil works projects, such as water distribution systems or structural engineering projects which are typically performed by civil and mechanical engineering students. At Villanova University, our civil and environmental engineering and mechanical engineering faculty and students have been involved in such projects for about seven years. However, there is also a lot of scope for electrical and computer engineering students to get involved in projects in the areas of power and communications. At Villanova University, we have recently started to develop a number of international projects that are involving electrical and computer engineering students. The projects to date include micro hydroelectric power projects (in collaboration with mechanical engineering colleagues) in both Nicaragua and the Philippines. We also have solar power projects being designed for Bali, Indonesia, the Democratic Republic of Congo and Tanzania. We are also working on a project to provide improved health care through text messaging using a cell phone infrastructure in Nicaragua (this project is being done in coordination with our Nursing colleagues). Some of these projects are categorized as social entrepreneurship projects as opposed to service learning projects and are being done in collaboration with colleagues in the Business School. In this paper we will describe these various projects involving electrical and computer engineering students and describe how these projects were started, the way that we are working with in-country partners, and the role of electrical and computer engineering students in these projects. We will also describe other potential projects that are under development.

Introduction

Engineers without Borders chapters are very active on university campuses in both the US and increasingly on university campuses throughout the world. These chapters are generally student-run and involve service projects within the US as well as in international settings, particularly in developing countries. These projects typically involve distribution of clean water to village communities although often also include small-scale hydroelectric power generation from small streams or waterfalls, and some structural engineering projects, e.g. building of schools, orphanages, etc. These projects are typically performed by civil engineering and mechanical engineering students and are motivating and often transformational, in the student's interest and desire to pursue an engineering career after graduation.

Having seen these examples of excellent engineering projects that were available to students of other engineering disciplines, I was inspired to develop project opportunities for electrical and computer engineering students. There are several areas where electrical and computer engineering (ECE) students may participate with regard to humanitarian projects including the areas of power generation and distribution, communications systems, and computer-based systems of various types. We have developed a number of projects, primarily in developing countries, that involve the design of electrical load controllers for micro-hydroelectric power systems, solar electric systems for remote buildings and a cell-phone and computer-based system for providing improved health care in rural communities. Each of these projects will be described in this paper as examples of potential projects that ECE students can get involved in.

Electronic Load Controller for Microhydroelectric Power Systems

Microhydroelectric systems are power systems that transform the kinetic energy contained in the flow and elevation drop of falling water to electrical energy. The water source may be a reservoir, dammed-up river, waterfall, or a partially diverted river or stream. The scale of microhydroelectric systems is typically ≤ 100kW. In the case of partially diverted rivers or streams, the water is directed through a settling tank down through a penstock to a powerhouse. Once the water enters the powerhouse, it is directed onto the blades of a turbine which rotates as it is struck by the water. The shaft of the turbine is coupled to the shaft of an electrical generator, typically a synchronous generator, which generates an electrical current and voltage. The voltage output from the generator is conditioned by an electrical load controller and then sent to a transformer which is interfaced to the electrical distribution lines. These systems can provide power for local village communities and can transform the lives of the members of the communities. The opportunity for electrical engineers in this type of project is the design of the electrical load controller that adjusts the impedance of the load, as seen by the generator, so that variations in the load and the power generation from the generator are matched. This ensures that the frequency and output voltage of the generator are maintained constant as the input water flow and output loads fluctuate. Typically, electrical resistance loads (e.g. water heating elements) are used as dump loads when the output load to the generator is low which could otherwise result in overspeeding and overvoltage of the generator, with the consequence of overcurrent and eventual thermal damage to the windings of the generator. A simple proportional-integral (PI) controller with appropriate sensors and relays can be designed to provide this control. Of course, appropriate protection circuitry needs to be designed as well. This makes an excellent senior

design project and is particularly motivating since it allows the students to see their electrical engineering theory being implemented in systems that are benefitting communities which do not have access to reliable electricity. We have had two student teams travel to Nicaragua and the Philippines to assess the opportunities for these microhydroelectric systems and they have performed the controller designs for their senior projects. Of course, the projects were not completed within one year and so additional student teams are taking over these projects for final design and implementation.

Solar Electric System Designs for Buildings in Developing Countries

In many developing countries, particularly around the tropics, there is plenty of sunshine available and so there is an excellent opportunity to provide reliable electric supply from solar energy. Solar panels have dropped significantly in price over the last few years and are also more widely available worldwide. This produces an excellent opportunity for students to design and implement solar electric systems for buildings in developing countries. A typical stand-alone solar electric system comprises batteries, solar panels, a charge controller, an inverter and dc and ac loads, as well as breakers, switches, wiring, panel boxes, etc. The design of a stand-alone solar electric system is generally straightforward and undergraduate EE students are quite capable of designing such systems. We have recently had student design teams work on the design of solar electric systems for office buildings in Bali, Indonesia, a health clinic in Tanzania, and a community of buildings in the Democratic Republic of the Congo. These opportunities came up primarily through alumni who had heard about a 4kW solar electric system that we had designed and implemented on our engineering building at Villanova University. Reading articles on this system in the Alumni magazine prompted the alumni to contact us and led to the student projects. We have also had one project brought to our attention through the Villanova Engineers without Borders chapter.

One of the challenges with these projects is finding local weather and climate data, to estimate the available solar insolation for potential conversion to electrical energy. A second challenge is to find local suppliers for components. The Internet has proven to be a very useful resource for obtaining supplier information in many developing countries.

The designs of these systems are in process and are expected to be implemented within the next year.

Cell Phone and Computer-Based Rural Health Care System

There is very limited access to quality health care in many rural communities of the world. We are working on a project in the rural communities surrounding the town of Wasala, in Nicaragua. Our mechanical engineering students and faculty and nursing students and faculty have had a relationship over several years with the communities surrounding Waslala centered around the parish. The mechanical engineers have worked on designing and implementing clean water distribution systems and microhydroelectric systems and our nursing colleagues have conducted health promotion clinics.

The only hospital in the area is located in the town of Waslala. Since the roads are largely unpaved and the communities are reachable only by horseback or on foot, it takes several hours and much hardship to travel to the town's hospital. Therefore, rural dwellers avoid this journey as far as possible, relying largely on lay health workers that serve their particular communities. Since the lay health workers are minimally trained, potentially emergent medical conditions can go unnoticed for too long.

A practical solution to this problem is to train the lay health workers to record the raw medical data in the field and to transfer it to a remotely located computer system by means of the ubiquitous cellular telecommunication network. The use of readily available telecommunication infrastructure lowers the upfront capital expenditure. In addition, by choosing to transfer the medical data over the short messaging system (SMS), the ongoing operational costs are minimized as well. Once the raw medical data is transferred to the remote computer, it can be processed using algorithms in real time to provide preliminary diagnostics. The system also generates SMS alerts to notify the health worker that the patient has to be brought into the hospital.

We have a team of undergraduate ECE students working with nursing students and faculty on the design and implementation of this system. These students are working on the system design as a senior design project. Both nursing and ECE students and faculty traveled to Nicaragua in May 2010 to perform an assessment of the telecommunications infrastructure and to interview community health workers to better understand how they could use such a system. The ECE students have developed an initial prototype system where data can be transmitted from a cell phone in a community to a modem interfaced to a computer located in the town. A team of ECE and nursing students and faculty will be traveling down to Nicaragua in early October to field trial this first generation system. Further development will be done and software on the town's computer will be upgraded and a second team of students/faculty will make a trip over the winter break to address any hardware/software issues with the system.

An additional component of this project is to make it technically and economically sustainable. We are working with students and faculty in the Villanova School of Business to help us develop a business model that will ensure sustainability of this health care system.

Conclusions

We have described a number of projects that we have ECE students working on in developing countries to improve power and health care infrastructure. These technologies are being developed in senior design projects as well as graduate independent studies. The projects have typically been brought to our attention through our network of alumni as well as building on existing relationships with other departments at Villanova University. These projects offer the opportunity for students to see the impact of their ECE skills on benefitting mankind and are very motivating and inspiring to students.

We are developing some new projects centered around the design of high efficiency, low power biomedical devices, that can be used with low power sources. This is another important area

where ECE students can contribute to the service of others. We will report on these projects in the future.

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