Photovoltaic System Installation in Belize

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California Polytechnic State University's National Electrical Contractors Association Student Chapter (NECA) was selected by the ELECTRI Council to take part in its Student Passport Initiative program, through which participants engage in meaningful service-learning experiences in developing communities. The team was tasked with the design and construction of a photovoltaic system for San Pedro Roman Catholic Primary School in San Pedro, Belize, with the purpose of enabling the school to achieve carbon neutrality with respect to utility grid power consumption. The team of five students collaborated primarily with two professors, two alumni, and an accomplished electrical contractor from Belize to perform six months of design and preconstruction work before ultimately delivering a fourteen-panel photovoltaic system with a projected average output of 13.4 kilowatt-hours per day. My role on this project was to manage shipping of materials and equipment from San Luis Obispo, California to Belize City, Belize, and to provide construction labor during the system's installation. I worked directly with our NECA student scheduler and interfaced with our NECA student cost estimator during preconstruction. This project has provided outstanding lessons learned and has aided me in my professional development by demonstrating the incredible logistics and planning necessary to complete international projects.

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Introduction

San Pedro is a town on the island of Ambergris Caye in Belize. The town is home to San Pedro Roman Catholic Primary School, a public school serving roughly 900 students from Belize, El Salvador, Guatemala, and Honduras. Funding for teachers' salaries is provided by the Government of Belize, with all additional costs funded through donations.

In July of 2016, David Mulder represented the California Polytechnic State University National Electrical Contractors Association Student Chapter (NECA) during the ELECTRI Council meeting in Napa, California. The Chapter was awarded the 2016 Student Passport Initiative and received a grant of up to $20,000 to install a complete and operational photovoltaic array for San Pedro Primary School in order to reduce dependence on the local electricity grid, encourage carbon neutrality, strive for net-zero consumption, build teamwork and better a community. The faculty advisors and several students began work with a preconstruction site visit. After, the team began design, scheduling, estimating, and procurement of the aforementioned system.

Key Factors & Process

My personal scope of work for this project included shipping procurement and management as well as the provision of construction labor. My work began in August, when I contacted various shipping companies in order to acquire quotes to ship our materials and equipment from San Luis Obispo to San Pedro. Without estimates on container count and size, pricing was difficult to find and services could not easily be compared. I temporarily concluded that we would work with Reynolds Shipping, a small company that ships from Los Angeles to Belize. However, the timing and availability of their services could not be predicted, and the formation of additional shipping contracts would have been necessary. Using invaluable advice from our advisor, I searched for a larger company that would

ship from San Luis Obispo to San Pedro under a single contract. I found Air Parcel Express, acquired a quote to ship from San Luis Obispo to Belize City, and confirmed that our contact in San Pedro, Eddie Halliday, would arrange shipping by barge from Belize City to San Pedro. The shipment ultimately faced five separate delays, including rail delays, a delay caused by a boat departure mistakenly scheduled on a holiday, and an unforeseen barge detour that resulted in the cargo being stuck in Guatemala City for several days. These shipping delays combined with our team's packing delays resulted in a departure date from San Luis Obispo of October 25th and an arrival date in San Pedro of December 17th, several days after the team had arrived in Belize and began construction.

Upon arrival in Belize, my construction work began with trenching. The solar panels were to be installed on the roof of a building over one hundred feet away from the main panel. Accordingly, the line from the roof ran through underground conduit before surfacing and running up and around the administration building in which the main panel was located. After trenching, I helped install the final lengths of conduit and mounted them on the exterior wall of the building before compacting soil around the conduit and filling the trenches. I deconstructed the cargo crates and hauled solar panels, metal framing, and tools to the installation site. I cut and preassembled solar racking components, drilled and caulked wall penetrations, and laid out the wall-mounted inverter. Additionally, I cleaned the solar panels, swept our work area, and removed waste from the site.

New Knowledge

I developed a great deal of new knowledge from this project in each of its phases. The preconstruction phase became highly educational for me when I was able to experience the ways in which the scope, schedule, and budget of an international construction project are so critically and tangibly dependent on each other. Construction projects truly require interdisciplinary collaboration between the designers and builders in order to achieve optimal success. Additionally, the project's design provided me with a deeper understanding of the various components necessary to construct an operational photovoltaic system. Gaining exposure to each facet of this project's planning has provided me with general knowledge applicable to most construction projects as well as specific knowledge that will increase my management abilities for comparable projects.

The construction phase of this project was one of my first experiences with construction labor and provided me with an appreciation for the problem-solving nearly always required during construction. No survey is complete, nor design perfect – constructors must possess the ability to pragmatically adapt to design discrepancies and unforeseen conditions in order to ensure that a functioning and operational project is delivered. Construction is full of financial, legal, and safety risks that absolutely must be addressed. Finally, participating in the construction of this project gave me invaluable insight regarding team dynamics and the various interests and motivations that shape individual and team success.

Deliverables

The final deliverable for this project was a photovoltaic system with four main components including fourteen SunPower E19 / 425 solar panels, a MidNite MNPV4-MC4 Solar Array Combiner, an OutBack Radian Series GS8048 Grid/Hybrid Inverter/Charger, and an ASCO 7000-SERIES 240V 50-60hz Power Transfer Switch. The system is projected to generate an average of 13.4 kilowatt-hours per day, or 4,898 kilowatt-hours per year, roughly 124% of the school's administration building's historical average annual energy usage.

Lessons Learned

This project and its various difficulties provided extensive lessons learned for the team. One of the most important lessons is the importance of pull, rather than push, scheduling – it is highly important to specifically define project goals and milestones before working backward to find and employ strategies that enable the project to be delivered on time and within budget. If the team works disjointedly and without a unified understanding of the required workflow, chances of success are greatly diminished, especially with time-sensitive projects.

An additional lesson learned regards the necessity of contingency. Contingency for unforeseen costs and schedule delays cannot be ignored. The team nearly missed the December installation window because it ate into the contingency built into the shipping schedule. As a result, any additional delay to the cargo's arrival in Belize would have resulted in the team's inability to complete installation of the photovoltaic system until March 2017 or later.

A final lesson learned is based on the importance of aligning the interests of all project contractors. For instance, the shipping contract with Air Parcel Express provided the company with no incentives to help the team maintain its schedule, and as a result, tracking the shipment and ensuring its timely delivery proved incredibly difficult. This is why construction contracts typically include project delivery dates and provisions for liquidated damages – so that the general contractor has incentive to deliver the project by a date that makes the project financially viable for the owner. Subcontracts often also include incentives for timely completion of work, and the lack of these provisions in our shipping contract was nearly disastrous toward the project's success. It is important and simply optimal for all interests to be aligned.

Figure 1: Solar panels installed for San Pedro Roman Catholic Primary School.

Future Application of New Knowledge & Lessons Learned

As a student aspiring to work as a construction manager for a real estate development company, the new knowledge gained and lessons learned on this project provide considerable value for my career. The construction manager represents the owner and their interests and must assemble a team of designers, constructors, and consultants that will collaborate to provide quantifiable value to the project. As is being discovered in the construction industry, it is crucial to form this team quickly and manage its workflow to ensure that it creates the aforementioned value and enables the investment to achieve or surpass its expected returns. The industry is constantly evolving, and interdisciplinary collaboration and integration are undeniably necessary to achieve the greatest degree of success.