San Pedro Roman Catholic Primary School Photovoltaic Project (Belize)

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In December 2016, the California Polytechnic State University National Electrical Contractors Association (NECA) Student Chapter, along with Construction Management faculty and alumni/industry members, installed a photovoltaic system in San Pedro, Belize. This student-led team won the Student Passport Initiative grant from ELECTRI International, with the purpose of designing and constructing a photovoltaic system for the San Pedro Roman Catholic Primary School, in order to reduce dependence on the grid, encourage carbon neutrality, and aim for net-zero energy consumption. This paper will discuss the preconstruction tasks associated with the project, focusing mainly on maintaining the schedule, the installation of the system in-country, and lessons learned.

Key Words: Photovoltaic System, Scheduling, International Projects, Material Procurement

Introduction

The San Pedro Roman Catholic Primary School is a public school located on the island of Ambergris Caye, and is the largest school in the area, serving over 700 kids. Considerable electricity costs and reliance on a somewhat unsteady utility grid led to the introduction of this project idea. Originating from the NECA Student Chapter of the University of Kansas, the project was ultimately awarded to the Cal Poly Chapter a few years later, and our team earned a $20,000 grant from ELECTRI International. After award, student team members and two faculty members took a preconstruction site visit to evaluate the jobsite and the in-country situation. The design of the system was finalized to include fourteen (14) photovoltaic panels, an inverter, an automatic transfer switch (ATS), and all necessary connections to the school's existing electrical system.

Key Factors

Contingency

Contingency was a huge factor in this project in two ways. The term "contingency" is usually used only in monetary terms of the construction budget. In the case of this project, I am using it as a term for both budget contingency and schedule contingency. On one hand, the budget contingency was a major factor in this project because we did not have an adequate amount set aside as contingency. Our initial budget included less than $800 as contingency. As a result of design consequences, we ended up needing around $3,000 in contingency to pay for excess tools and materials needed, specifically batteries to round out the PV system. These batteries were sent to San Pedro post-installation trip. One the other hand, schedule contingency (i.e. float) was a major factor in the project because of the shipping challenges that occurred. Due to the lateness of plan finalization, only about eight (8) days were

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allowed into the schedule for shipping. These 8 days ended up being eaten up by the troublesome international shipping, and the shipment was ultimately two (2) days behind schedule.

Schedule Maintenance

Maintaining the overall schedule of the project was my main role on the team. This required constant communication and collaboration with the team member in charge of the material shipment, Austin Stewart, because the shipment was the main aspect to our schedule. Working together with Austin, we ran into many hurdles with international communication regarding the shipment. We were challenged communicating with both the international shipping company and our man-on-the-ground in Belize, local electrician Eddy Halladay. The communication challenges led to late updates on the schedule, which made it difficult to keep the whole team informed of what was happening with our shipment. Once the shipment was picked up at the CM Building in San Luis Obispo, it was somewhat out of our hands as to how long it took to get to Belize, and it ended up taking much longer than expected and planned. Because of both the communication and shipping delays, the schedule contingency dwindled down. With each hiccup in shipping, an update to the schedule was needed. At the end of the day, there was a total of eleven (11) schedule revisions. Total shipping time went from under thirty (30) days, to forty-two (42) total days. Keeping the schedule updated allowed our team to make educated decisions as to what days we needed to start/end work, and also provided essential information when the installation trip was in danger of postponement. Later in this paper, the "Scheduled & Actual Project Milestones" section illustrates which legs in the shipment caused the delay, and for how long.

Physical Installation

Once we got in-country, we were able to turn our attention to the physical construction of the system. Key factors during the installation included delegating tasks between team members, the aforementioned material shipment delay, dealing with constant hot weather and sporadic rain showers, and some incorrect materials. Because of the material shipment delay, we had about three (3) planned installation days without our materials on-site. Coincidentally, according to my schedule, we also had 3 total days set aside for "rest/float," which proved essential to completing our planned installation. We used these days to plan ahead and do as much labor as possible. We were able to set layouts for the panels, boxes, and inverter, and dig the 200+ foot trench for the conduit and wire connecting the PV system to the existing electrical room. Once the material shipment finally arrived, the team split into roughly two (2) crews, one mounting the PV panels and unistrut (see *Figure 2*), the other running conduit and pulling wire between connections (see *Figure 1*). As far as dealing with the weather, we began starting earlier in the morning to beat the heat, and during the many sporadic rain downpours, we stopped work altogether. When it was all said and done, the team's installation ended with one day to spare. Later, our team shipped the necessary batteries to round out the system, and it was fired up.

Figure 1: Crew 1 (mine) was tasked with conduit runs and wire pulling.

Figure 2: Crew 2 mounted the panels.

Scheduled & Actual Project Milestones

Below is a schedule summary that breaks down major preconstruction milestones in the project and illustrates whether the tasks occurred on or behind schedule. Tasks 6 through 9 occurred behind schedule.

Schedule Summary					
Milestone	**Title**	**Description**	**Scheduled Date**	**Actual Date**	**Location**
1	Precon Trip	Three (3) team members take trip to evaluate site and in-country situation	June 28-29, 2016	On Schedule	San Pedro, BZ
2	ELECTRI Presentation	Two (2) team members present to the council and win grant	June 30- July 4, 2016	On Schedule	Napa, CA, USA
3	Final Design Complete	Through industry help, CM 411 class, and team work, PV layout and electrical design completed	December 12, 2016	On Schedule	SLO, CA, USA
4	Shipping Crates Built, Materials/Tools Packed	Three (3) team members complete construction of the shipping crates and pack materials/tools	Oct. 21, 2016	On Schedule	SLO, CA, USA
5	Shipment Sent Out	Shipment picked up from Cal Poly CM Building - SST	Oct. 25, 2016	On Schedule	SLO, CA, USA
6	Shipment from Port Everglades, FL	Shipment Secured, Ship Sails from Fort Lauderdale, Florida. Bound for Belize	Nov. 24, 2016	Dec. 3, 2016	Ft. Lauderdale, FL, USA
7	Customs	Shipment in Belize, Going through Customs	Nov. 28- Dec. 1, 2016	Dec. 7-12, 2016	Belize City, BZ
8	Shipment In-Country	Shipment sent from Belize City to San Pedro on Ambergris Caye	Dec. 2-4, 2016	Dec. 13-17, 2016	Belize
9	Shipment Arrives at Jobsite	Planned date of arrival for our shipment	Dec. 5, 2016	Dec. 17, 2016 (+12 days)	San Pedro Town, BZ
10	Team Arrives	Team gets to San Pedro Town ready to begin installation	Dec. 14, 2016	On Schedule	San Pedro Town, BZ

Final Deliverables

The project ultimately delivered a fully functional photovoltaic system which included the following:

- Fourteen (14) SunPower E19 / 425 solar panels
- One (1) MidNite MNPV4-MC4 Solar Array Combiner
- One (1) OutBack Radian Series GS8048 Grid/Hybrid Inverter/Charger
- One (1) ASCO 7000-SERIES 240V 50-60hz Power Transfer Switch

Lessons Learned

I learned much more through this project than initially expected. Not only did I learn about physical construction skills and processes in terms of how photovoltaic systems work, but I also learned about what it really takes to get a construction project done, starting from an idea to securing the final piece. Contingency is one of the most important aspects during preconstruction planning. “Plan A” rarely goes perfectly, so it is necessary to plan ahead in both time and budget. In terms of scheduling, it is much better to utilize pull planning. It is essential to hit milestones on time and include a realistic and safe amount of float. Luckily, our delays only pushed us right to edge and not off it, and we were able to install during the planned time period. From the installation labor, I learned about and got some firsthand experience with delegating construction tasks and about how crews can work.

As a Construction Management student who is first going into military service as a Marine Corps officer after graduation, this project particularly resonated with me. This is because we were able to go into a community and leave the place better and the people thankful. The Marine Corps is a worldwide force which regularly races out to natural disaster and other troubled areas in need to provide help. Thus, the lessons learned and experience of this project provides me great value for my future career, in both the military and when I jump back into the construction industry.