Skip the Grid: Installation of Solar Powered Refrigeration in the Navajo Nation

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The Skip the Grid project was a project completed with the joint efforts of California Polytechnic State University, San Luis Obispo (Cal Poly) and many other company sponsors including Solv Energy, Dometic, Goal Zero and Heart of America a nonprofit. Skip the Grid's project goal and outcomes was to improve the quality of life and provide clean sustainable off grid energy to families within the Navajo Nation. The Navajo Nation is located in the Four Corners region of the United States with approximately a third of its residents without the means or circumstances to be tied into grid level power. During the Covid-19 epidemic, life without grid level power was worsened as many of the children had to participate in distance learning, often without the tools or resources in order to be successful. The partners of the Skip the Grid project worked with community leaders of the Red Mesa school district to identify families that were the most impacted, to provide them solar power and the necessary school supplies. When completed the Skip the Grid team had in all supplied eleven families a solar powered system that provided power, refrigeration, and light.

Key Words: Solar, Refrigeration, Navajo Nation, Skip the Grid, Renewable Energy

Introduction

This interdisciplinary project provided solar power, refrigeration, and lighting to twelve families of the Navajo Nation. Cal Poly students and faculty from electrical engineering, mechanical engineering, construction management, graphic communications, and political science, along with Heart of America, and Solv Energy worked to provide and install the amenities for the project made possible by generous contributions from numerous supporters. I served as a superintendent and was responsible for the planning, sequencing, and logistics for one of the two teams on the project. The other team's superintendent and I were responsible for creating a tool list, materials list, and pre task plan for the installation, coordination, and supervision of the solar power system at each home.

Background

The Navajo Nation spans over 17 million acres in the Four Corners region of the United States, with approximately 175,000 residents living within their borders. Many of the families in the Navajo Nation do not have power or rely on generators to supply power to their homes. Approximately thirty

percent of the households do not have permanent grid tied power and are unlikely to get it soon, if ever. Heart of America is an educational non-profit organization that works to support children that do not have the resources to grow up successfully. Solv Energy is the largest grid level solar energy contractor specializing in construction and operation of solar PV plants. Cal Poly partnered up with Heart of America and Solv Energy to send a team of students to the Navajo Nation to install solar panels, a refrigerator, and lights in selected homes. Through the use of Goal Zero (battery/inverter, lights, PV) and Dometic (DC/AC Dual zone refrigerator/freezer) products coupled with support and help from Heart of America and Solv Energy we would set out to provide power to 12 homes. These homes were selected by the Red Mesa, AZ school district that identified families that did not have power – which hindered the children's ability to be successful in school.

I really enjoy hands on experiences so when presented with this opportunity to install solar power refrigeration, I jumped at it. The hands on labs for Cal Poly's curriculum were some of my favorites. I felt that I was ready to take on this challenge through my experiences from my classes, internships and extracurricular activities. Some of the classes that prepared me for this project included, residential construction, for building methods. Commercial construction, where I was educated on tool safety and management, creating pre task plans and scheduling. Jobsite construction management taught me site safety management. Specialties gave me familiarity with electrical and mechanical systems. My internships taught me the importance of clear communication, and collaboration. Being a member of the ASC Electrical team was great preparation for real life problem solving as well as working in a team setting. All of these skills applied directly to the work that would come in this project.

Process

Funding

The amount of support we received for the project was tremendous. The funding provided help supply our lists of tools, equipment, and other necessary supplies. Sponsors of the project include, Heart of America, Live Action, Goal Zero, Dometic, Cupertino Electric, Prime Electric, Solv Energy, Quiring General and many other industry sponsors. The generous donations we received ultimately allowed us to create a budget that would include our travel, and lodging. Thanks to our sponsors, we were fortunate to have a sufficient budget for the project including a small contingency for fasteners and sealants to address unforeseen conditions that may be encountered when arriving to the site, several hours from the nearest hardware store.

System Design

The design for the solar Photovoltaic (PV) system evolved throughout the development of this project. After several iterations and calculations from our engineering colleagues the equipment for the system proposed for our original for construction design would consist of two Goal Zero Boulder 100 watt Solar Panel, an 8mm 30 foot extension cord, a 1 to 4 High Power 8mm connector, a 1000x portable power station, one Dometic 75 liter refrigerator, and two Light-A-Life 350 LED lights. Following calculations performed by the engineering students on the team and through consultation with the Goal Zero Team, the Goal Zero determined that they would need to supply more panels to provide adequate power, so the system could successfully power the Dometic fridge,. We revised our planning

to include two Boulder 200 watt Solar Panel Briefcases (which is essentially two 100 panels connected side by side, but now instead of two 100 panels we would have four with the briefcase). When we arrived to the project we found that we were sent four 100 Watt panels for each installation, providing the best solution for the planned installations.

Figure 1: PV System (Two Power Stations, One Dometic Refrigerator and Four 100 watt Solar Panels)

Installation Planning

Our original installation plan was to mount the solar panels on every roof. When we received photos of the homes from a visit by Heart of America, we realized that we may not be able to mount all of the panels on the roof due to the poor conditions of some of the roofs. We then began brainstorming alternative mounting systems. From there we devised a plan to roof mount where we could and create a ground mounting system for the panels comprised of Unistrut that could be secured to the side of the home. After we finalized a design for the ground mounting, our next course of action was to identify and establish the houses that would be roof mounted and the houses that would be mounted on the ground. We further analyzed the homes to identify the best orientation for the placement of the panels. This was a difficult portion of planning due to the lack of home addresses and street views of the homes, as they are in a very remote area traversed by miles of dirt roads. We were given coordinates of the homes however, so we used google earth satellite imaging as best we could to identify the orientation of the homes, and in turn predict the most optimal orientation for the panels. However, shortly before we left, we were instructed that we were to forego the ground mounting system and install the panels on every roof instead.

Team Designation

Our original concept was two split into the two teams which were to complete three houses a day. The teams were given the designations, the gold team and the green team. The teams would consist of the following Cal Poly members. Gold team was to be Ryan Schacherbauer, Heather Sailor, Tanner

Wells, Daneille Greger and faculty included Jeong Woo and Jacques Belanger. The green team would be Connor Avrit, Sydney Sitton, Zane Hampton, Janelle Cruz and faculty member Joe Cleary. We figured that we would split the teams to have two construction management majors, one mechanical engineering major on each team, with one electrical engineering student on one team and a political science major on the other. When we arrived, we kept the Cal Poly members for each team including faculty with the exception of Ryan and I switching teams. We also would have the addition of Heart of America members, Solv Energy members, and our Navajo ambassadors.

Tools List

The first responsibility that I was assigned along with Ryan Schacherbauer was to create a tools list, identifying all the tools that could potentially be used on this project. We created a excel sheet that identified the tool, manufacturer, model, quantity, price and a link to the website for the tool. To begin preparation for the list we thoroughly reviewed our plans for installation, trying to conceptualize every tool we would need in preparation for each style of preparation. Some of the major categories included power tools, hand tools, and miscellaneous tools. We made a preliminary draft, that was revised to a final draft.

Practice Day

The weekend before we left for the project, we had a practice installation day on one of the tiny houses constructed in the Residential Construction class. This day was the day to practice both the roof installation and our design for the ground mount. We divided into our designated teams for the project, one team worked on the roof installation while the other worked on the ground mounting system. This process was helpful in preparation for the trip to give our group a hands on learning experience, becoming familiar with the tools and materials that would be regularly used.

Pre Task Plan

One of the other deliverables of the project was the pre-task plan, this one I worked on again with Ryan Schacherbauer. For this deliverable we went through each house individually and identified all the installation steps for each of the major pieces of equipment including the solar panels, the portable power station, and Dometic cooler. In addition, for all of the installation steps we also outlined all of the potential challenges that would accompany said pieces of equipment. We used our best judgement from the photos available to try to anticipate the challenges and risks we would face to install each piece at every home.

Logistics, Travel and Organization

Once arrived in Durango, Colorado we would split into three different teams. One team would head straight to the hotel in Bluff, Utah. The second team would go pick up the items we had shipped from UPS. The third and final team which included the CM students would go to Home Depot to pick up any and all supplies we weren't able to ship there. The following day we would head to Red Mesa which was roughly 40 minutes to the South in Arizona. Once arrived in Red Mesa at the school, together we split and organized all of our tools for the two teams to be packaged into our respective vehicles. After organizing and before packing the cars we started the day with some stretch and flex to loosen up.

Figure 2: Organizing Tools

Construction Day One

Once finished stretching, we began loading the cars with all of the tools and equipment we would use throughout the day. The plan for the day would be that both teams would work together on the first home then divide after to complete two homes each. The first home was really our first and final dry run. Not that the practice installation day wasn't helpful, but I think we were a little unprepared for what we would face when we were actually out there. This was the first time working on the roofs of homes, and the first time we really had to convey our ideas to the owner for installing the panels in the most optimal place and thus where the power station and cooler should be located. Additionally with all of the people working at the first house I believe that we were a little unproductive, with too many "cooks in the kitchen" so to speak. Needless to say we ran over our budgeted time on the first finishing in about two and a half hours to three hours. The actual construction consisted of Joe Cleary, Ryan Schacherbauer and I working on the roof installing all of the panels. Our plan was to attach the panels to rafters in the roof which we were able to locate with our stud finders. Other roles included various members passing the panels up the ladder to us on the roof and a separate group working with the homeowner on the inside to determine the best place in relation to the panels for the power station and the cooler. Once the panels were secured to the roof, we ran the extension cord from the panels on the roof through a hole that we drilled through the wall to the power station. Once the extension cord was fed through the wall and connected to the power station, we set up the LED lights within the home and sealed and caulked the hole in the wall.

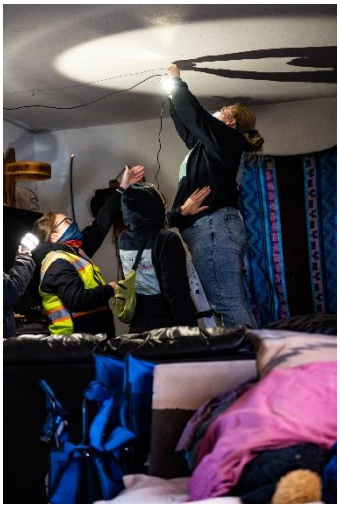

Figure 3: Setting Up Lights

Figure 4: Feeding Extension Wire Through the Wall

After the first home we would then move on to our next and final homes of the day for each team. Our next home we would complete in our individual teams. My teams second home ran smoother than the first home, taking about an hour and a half to two to complete. On this house Jeong Woo and I would work on the roof to secure the panels to the roof while there was a group on the ground preparing the panels and working the owner to determine the best place to house the power station and cooler.

Figure 5: Panel Installation on Second Home

Day One Analysis and Planning for Day Two

In the first day since both teams in aggregate had only completed three houses that left nine houses left to complete on the second day, whereas our original plan was to complete three houses per team per day to sum to 12. Since we were a far cry short of our goal on the first day, we held a meeting on the first night to discuss what could have been the results of our shortcomings. The meeting which was led by Sydney Sitton was to review the positives and negatives of the day. Our plus delta gave us quality insight on what we could improve on. After our meeting on the first night our goal to complete the remaining nine homes was to complete each home in just 60 minutes. So ready to conquer the day we set out the next day early to pre-drill the holes in the panels and load all of the equipment into the cars. With our new strategies and plans in place we headed out to start the day. The plan for the second day was that my team would install for five houses and the other team would install for four houses.

Day Two Construction

Our first house was a metal roof hogan style home (the traditional octagonal Navajo Home). Jeong and I installed all four panels on the south octagonal facet of the roof while the inside team worked to determine the best position for the power station and Dometic cooler. I was amazed and proud of how fast and diligently we worked on this house, after the installation of the panels, cooler and power station and caulking and sealing of the cord through the wall we met our goal of completing the installation in under an hour.

Figure 6: First House Install on Second Day

The next home we installed presented its own challenges. The south oriented roof was scheduled to be reshingled but at the time did not have any shingles, just exposed OSB. Along with the shingleless roof that we would be installing panels on there were holes around the vents protruding through the roof and rot in some spaces of the OSB. So while on the roof Jeong and I were cautious to stay away from the rot and openings in the roof. Another problem that arose was that our ladder was only 14 feet

tall and since the ground around the foundation was lowered our ladder couldn't reach the roof. We were fortunate though that the homeowner had an extension ladder that we were able to use. Once the panels were installed, we ran the extension cable through the wall above the back door to the kitchen were the power station and cooler would reside. After all was said and done this house was completed in just 3 minutes past the hour.

Figure 7: Second House on Second Day

The next house we would move on to next was relatively straight forward. This was one of the milder slopes of the roofs out of the houses we worked on. Jeong and I were able to both work on the roof to find the studs and install the panels in the optimal positions. Similar to the last house we ran the extension cord over the edge of the roof above the back door of the house to the kitchen. This house presented little challenges and we were able to complete this home in just 49 minutes.

Figure 8: Install of Panels on House Three

The house we worked on next was the steepest roof my team would work on. The slope hand in hand with the metal roof proved to present its own challenges, but Jeong and I were able to safely install all four panels with myself working on the roof and Jeong working from the ladder. The steepness of the roof did cause us too take a little longer during installation.

Figure 9: Panel Install on Home Four

Additionally after installation of the components of the system inside the family expressed their wishes that one of the two lights be moved to fits their needs more accurately. This in turn also resulted in more time spent on this house and overall the completion of this home took just short of an hour and a half.

Our fifth house of the day was a trailer/mobile home of sorts. When were assessing this to determine the optimal place to situate the panels we realized that due to the dome shaped of roof and the material that the roof was made out of that we would not be able install the panels directly on the roof. Unsure of what to do we brainstormed for a little to figure alternative mounting positions on the house. After consulting with the owner about possible wall mounting for the panels and identifying the best places for the interior components, we were still uncertain of the correct course of action. After reviewing the inside of the house we discovered that the homeowners had recently received access to electricity and had a running refrigerator and freezer. While our goal was to install solar powered refrigeration to families in need, we came to the conclusion that there was another family that was more in need of the systems we were installing and so we decided to not install on this home. This was partially due to the fact that this family did just recently receive power from the grid and had a refrigerator and partially because due to the conditions of the home we couldn't install the panels on the roof and because of the prevalence of theft we weren't comfortable with the idea of installing the panels on the ground or the wall. So as unfortunate as it was, we as a group we decided that there would be another family in more need of the system and return the products to the school so that they could determine a new family to receive the solar powered refrigerator.

Results

As a group we learned many lessons throughout the entirety of this project. Some of them simple and some of them proved to be more than we had predicted and planned for the project. After our meeting after the first night of construction we came together as a group and collectively identified areas where we exceled and brainstormed ideas for where we could improve. Having to complete each house in just 60 minutes for the next day we recognized that the first ten minutes of each house was crucial. In that time we should determine the optimal place for the panels, consult with the owner and find the best place for the interior components. Other lessons learned concluded that tidiness proved proficient. It was important that not only our tools were organized before hand and our most utilized tools were easy to access, but also that after we used any tool it was returned to its proper place, given that we were at a loss if we lost anything as the closest hardware store or home depot was hours away. Along with this I found it extremely productive to store all the tools and materials that would be used for the roof installation in a bag that could be taken up onto the roof so there was no wasted time retrieving tools. Another method we implemented to save time was to work and prepare panels a house ahead if someone had the spare time. Working in an interdisciplinary group was great in that there were multiple areas of expertise and different perspectives for problem solving. However at the same time, having different expertise sometimes meant debating the best course of action for entirely too long. For future project teams it will only be to their benefit if they have two impact drivers and two drills per team. Also, do not forget hammers and if possible due to room restriction in the vehicles it would be best to have longer ladders.

Conclusion

This project provided solar powered refrigeration and interior lighting to eleven families in need in the Navajo Nation and the materials to support one additional family. It was through the generosity of our many project sponsors and support of our department and faculty that this project was able to be realized. Together we were able to provide basic necessities to these Navajo families, power to charge devices, refrigeration to store healthier food alternatives to canned food and light to break down the barriers the children faced who couldn’t work during the dark of night to complete their schoolwork. This is a sustainable solution for these families that will provide them the much needed technology to improve their quality of life and remove obstacles to educational achievement of the future generations.