Skip The Grid: Empowering the Navajo Nation Through Solar Energy

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Skip the Grid is an interdisciplinary service project through California Polytechnic State University, San Luis Obispo (Cal Poly) where students and faculty partnered with sponsors including SOLV Energy and Goal Zero, and facilitation by Heart of America, an educational equity non-profit, to bring solar power to 27 families of school aged children in the Navajo Nation. The Navajo Nation is a historically disadvantaged community which lacks the infrastructure and financial capacity to provide electrical service to about a third of the families living on the reservation. Families in the Red Mesa and Chinle School Districts were the focus for this initiative in addressing their needs for light and electricity to support their educational needs. With plans for installing environmentally and socially equitable solar energy systems, all stakeholders involved were able to incorporate lessons learned based on prior implementations of this project from previous years. Although faced with several logistical challenges, the coordination of these interdisciplinary groups of students delivered the successful installation of solar panels to these 27 families in the reservation. These families' lives have seen the tremendous positive impact in having access to clean, affordable off-grid electricity. This paper documents how pre-task planning and means and methods were developed, assessed, improved, and incorporated into the 2023 implementation of the Skip the Grid project, as well as recording lessons learned for future groups to reference.

Key Words: Interdisciplinary Projects, Renewable Energy, Sustainability, Pre-Task Planning, Means and Methods

Introduction

The interdisciplinary service project known as Skip the Grid was conducted through California Polytechnic State University, San Luis Obispo (Cal Poly). Students, faculty, and sponsors such as SOLV Energy and Goal Zero joined forces, with support from Heart of America, an educational equity non-profit. Together, they worked towards providing solar power to 27 families residing in the Navajo Nation, who have school-aged children. Under the facilitation of non-profit organization Heart of America (HOA) and their partnership with solar company SOLV Energy, students and faculty of California Polytechnic State University, San Luis Obispo (Cal Poly) were able to collaborate with various stakeholders to determine project logistics and coordination. Student teams comprised of one SOLV energy member, one HOA Member, one assigned Navajo liaison, and an interdisciplinary group of students (I.e., one-two Construction Management student(s), one-two Mechanical Engineering or similar discipline student(s), and one-two student(s) of other disciplines including Economics, Spanish, Architecture, Mathematics, Graphic Communications, etc.). Nonetheless, this experience exemplified the epitome of Cal Poly's "learn by doing" philosophy – utilizing our prior coursework and working among an interdisciplinary team showcased how a group of individuals with different academic disciplines can come together to complete a project of this scale. The planning, coordination, and execution of the project would essentially enable this year's project to install “off-grid” solar photovoltaic (PV) energy systems to 27 families within both the Red Mesa and Chinle school districts.

Background

Background of the Navajo Nation

The Navajo Nation spans over 17 million acres in the Four Corners region of the United States, as it stretches across portions of northeastern Arizona, southeastern Utah, and northwestern New Mexico. With approximately 175,000 residents living within their borders, the Navajo Nation is the largest federally recognized tribe in the United States, both in terms of land area and population. However, as a historically marginalized community, the Navajo Nation faces challenges in infrastructure and financial resources to provide electricity to about one-third of families on the reservation. Thus, the primary focus of this initiative was to address the needs of families with school-aged children in the Red Mesa and Chinle School Districts by providing them with access to lighting and electricity, crucial for supporting their educational requirements.

Still attempting to recover from the impacts of the COVID-19 Pandemic, it wasn’t until January 20th, 2023, that the Navajo Nation was able to uplift their mask mandate, slowly acclimating to life without concerns of significant virus spread and contraction. Although it has been a hot spot for resource extraction over the past 150 years, the Navajo Nation and its people have yet to receive the infrastructure necessary to provide them with electricity. As a result, not having access to electricity has had several repercussions for Navajo Families: lack of access to running water, no source of reliable lighting, and a lack of heating and cooling systems during the extreme weathering months. In resolution, families have no other choice but to find means of compromise such as driving 1-1.5 hours once or twice a week to refill water for cooking and cleaning, or to refill gas to power their generators just to have temporary means of electricity. Nonetheless, it was essential for our Skip the Grid team to impact and simplify the lives of these families as they also sought to provide a better life for their children. Installing these PV systems tremendously impacted the children's ability to focus on their educational needs, particularly when the sun is no longer able to serve as their light source in the nighttime. When witnessing these conditions from our perspective, our goal was evident – with the guidance of Cal Poly Faculty, HOA, SOLV Energy, and the Goal Zero energy systems, we will coordinate the installation of off-grid, battery powered solar energy systems to support the educational accessibility to children and students of the Red Mesa and Chinle School districts.

Figure 1. Navajo home without electricity

Figure 2. Navajo home undergoing installation

Academic Preparation

I was chosen to be Co-lead of the Constuction Team for Skip the Grid and Team Captain for the Red Team, one of the five total installation teams elaborated upon in the team organization section. My responsibilities in leading this effort were focused on project management, including communication and coordination with teams at hands-in meetings, overseeing construction means and methods, and establishing roles within the practice installation days. In doing so, I was able to incorporate several aspects of prior coursework such as Jobsite Construction Management, Residential Construction Management, and Integrated Project Delivery. Integrated Project Delivery, CM 450, was heavily showcased in a project of this scale. This course emphasizes the importance of programming within a project as introducing all stakeholders to the project at an earlier time promotes a greater ability to efficiently plan for the project; thus, due to effective programming introduced in this project, all contributors could clearly outline any concerns pertaining to scope of work, lead times, schedule, or any other major milestones.

Prior to the 2023 project implementation, I garnered interest in this project following last year's completion – aspiring to utilize the skills learned from my Construction Management curriculum and apply it to a humanitarian project of this scale. Relying upon my knowledge gained from previous internships with PRIME Electric and Anning-Johnson, as well as networking skills gained through organizations such as CM Communities and Student Achievement (CM CASA), enabled me with the skills to facilitate and contribute to the success of my installation team and the overall project. Nonetheless, my overarching analysis and goal throughout the project was measuring the success of last year's team, implementing and improving means and methods, as well as overseeing the pre-task planning beginning from the practice install days up until the completion of the actual project. Commencing in late March 2023, this experience tremendously boosted my workmanship, leadership, and networking capabilities, all while further attracting me to sustainability and green building in construction.

Process

Team Organization

The composition of the Skip the Grid team was made up of faculty and students from various disciplines including Construction Management, Mechanical Engineering, Architecture, Spanish, Mathematics, Economics, Graphic Communications, and Environmental Engineering. Interested students in this project were selectively screened by Project Captain Heather Sailor with assistance from faculty advisors: Department Head Dr. Jeong Woo and Assistant Professor Joe Cleary. Nonetheless, these three leaders took responsibility for contact with main stakeholders while reporting information and action items to the remaining 19 students planned for travel. Tasks were delegated to the team leads of the respective teams: Construction Team, Education Team, Fundraising Team, Cultural Team, and Systems Engineering Team. This format essentially allowed for the interdisciplinary aspect of the project to take effect – responsibilities were accurately assigned to the respective teams to design and construct their plan for execution. This was crucial to meet the goal of streamlining communications at the weekly hands-in meetings held until the project travel date. Additionally, student groups would be broken out into 5 separate installation groups, ensuring there was at least one Mechanical Engineering Student, one Construction Management Student, while also ensuring this aligned with at least one person fulfilling the team roles of the following: 1) Roof installer, 2) Interior installer, 3) Solar Orientation Guide, 4) Panel assembly/additional installation assistance. These positions comprised the 5 installation teams: green team, gold team, red team, blue team, and purple team. Additionally, one member from HOA and one member from SOLV were assigned to these student teams to provide further assistance in all things pertaining to installation.

System Design

The solar PV system design remained consistent from the project's development beginning last year. The system itself consists of (4) 40” x 26.75” 100-watt solar panels, a 1000x Yeti portable battery, (2) portable 350 lumen portable LED lights, and a 30’ adapter cable to connect the panels to the battery. The major difference from last year's install is the removal of the Dometic refrigerator as it was to be installed at a later date by HOA; nonetheless, utilizing the success of last year's system simplified the need to understand the system’s limits and capabilities. Having this framework laid out only required the team to implement lessons learned as far as the installation of these systems.

General Installation Pre-Task Planning

Pre-task planning of this project was essential to understand all the logistics pertaining to tool use, construction safety, travel, and the overall breakdown and timeline of what construction would look like on a day-to-day basis. Constant communication with faculty leaders and project captain was critical to understanding milestones expected to be met by Cal Poly. Nonetheless, what was essential to developing a pre-task plan was our team’s practice build days – an area importantly emphasized due to the lack thereof in last year's project implementation. In the practice build days hosted, my responsibility as Construction Co-Lead was to fulfill the role of a construction expert and assist other students in learning how to navigate tools, ladder safety, and the Goal Zero systems. With the Residential Construction Management students completing residential sheds as part of their class deliverable, we were able to utilize these in completing a mock building day as if teams were legitimately completing these processes out on the reservation.

Figure 3. Practice Systems Training in the SST

Figure 4. Practice Exterior Installation (Left) and Interior Installation (Right)

Although practicing under ideal and controlled building conditions (the exact opposite of what students experienced), the important aspects to take away from these build days were 1) familiarizing ourselves with construction logistics such as safety and tool use, 2) understanding all of the Goal Zero system components, 3) constructing the framework for expected build day processes, and 4) determining the team dynamic amongst each build team and examining the development of teamwork and communication. These practice sessions also served as a means of determining what materials/equipment were necessary to complete tasks - items which were seen as unfit for the project were removed and alternative materials to be used on a conditional basis were proposed. Once the tool list was fully developed, another large portion of our pre-task planning was compartmentalizing the pack out toolboxes and dividing these into three separate groups - one section for the interior team, one section for the exterior roofing team, and one section for general use. This would ideally minimize on-site mobilization of students as the necessary tools and hardware were proactively distinguished.

Figure 5. Pre-planning tool organization (Left) and compartmentalization by role (Right) both before travel

Overall, these practice build days allowed me to work with faculty in developing an outline of what the actual installation should look like. The table below is a shortened and preliminary internal breakdown of what each student group was to do on a per-house basis, based on our practice evaluation. Utilizing this pre-task plan enabled groups to measure efficiency of their install times and evaluate areas of the plan which needed more efficiency.

Table 1

Preliminary Pre-Task Plan – Internal Outline for Construction Time

Time	Activity	Team Tasks
Before/ During Travel	Understanding the system and safety protocols	Fundamentals of Roof and Ladder Safety 1. Understanding ladder safety and utilization 2. Ensure proper PPE is prepped for the project 3. Utilize Google Earth coordinates to plan execution
Arrive on Site	Liaison greets family – gives introduction	Team begins stretch and flex to avoid body injury
0:00	Initial assessment	Assessing Roof Type, Condition, and Orientation 1. Solar Orientation 2. Determine: Is the roof safe enough to climb?
0:10	Huddle: roof/solar/ interior	Determining Appropriate PV Panel and battery Placement Location (in coordination with team)
0:15	Begin PV/ battery installation	Installing the panels on the Roof simultaneously with the installation of lights and battery place on interior
0:40	Manage connections	Connecting the wires after drilling wall hole, feeding wire, making connections, sealing hole, and ensuring cable management
0:50	Housekeeping items	Removing Tools/Trash/Debris from Roof/interior 1. Pack up vehicles
0:55	Homeowner training	Systems team members will train homeowner
1:00	On the move	Travel to next home (safely).

With this plan being the ideal timeline for what each house's completion would look like, it was without surprise (much like any project in construction) that there were several logistical issues which prevented teams from following this time outline. Initially, teams were prepared to receive housing coordinates from HOA to prepare for unforeseen housing conditions and develop a plan to successfully overcome such obstacles. Using Google Earth, these coordinates would assist in understanding potential housing conditions (i.e., the conditions and safety of roofs, solar orientation planning, ladder setup areas, etc.). However, coordinates were not sent out until about a day before the actual build days, limiting our ability to fully develop an efficient plan. Nonetheless, this translated into further logistical issues when it came to arriving at the homes and dealing with such unknown conditions, which varied on a house-to-house basis. In my team’s own experience, some logistical issues faced included navigating a roof with tires on the south facing end of it, working on different roof configurations such as a spandrel roof or hogan roof (different than the gable roof we practiced on), or even just interior issues with the placement of the battery. Overall, through the pre-task plan assessment, the framework was established for a constantly evolving means and methods.

Means and Methods

Before traveling to the reservation, the practice build days were essential in not only understanding our initial means and methods for the installations, but also taking the time to understand each other and how our different disciplines would mesh. Thus, we held 1 practice build day to understand safety protocols and determine our means and methods and held another build day within our actual build teams to figure out team dynamics and working styles before headed out to the reservation. Overall, this proved very effective as we were aware of how our internal processes would be run within our actual install teams. Within these sessions, communication, leadership, and coordination were all significantly improved, making our installations out on the reservation just that much easier.

Figure 6. Stretch and Flex led by Faculty, Joe Cleary at Red Mesa High School

Figure 7. Practice and implementation of prefabrication process at Red Mesa

Out on the reservation, Day 2 mocked what our remaining build days would consist of out on the reservation. On the morning of our initial build day, we utilized the Red Mesa High School as our "project base". Prior to beginning any work, a stretch and flex was completed to mitigate any bodily injury while moving materials or completing the installation after departure from the school (Figure 6). Utilizing the Red Mesa High School as our project home base allowed us to re-up on necessary equipment (solar panels, batteries, and lights) and proactively prefabricate our solar panel mounting brackets, reducing the amount of time we spent out in the field doing so (Figure 7). With our initial installation being done in combined teams, this assisted in our learning curve and allowed for more guidance since some of our teams during the remaining construction days would not have faculty supervision. Nonetheless, this project could not have been completed without the development of our problem-solving and teamwork skills led by our initial practice build days. Based on these experiences to practice our installation, the following is our overarching methodology to complete the project when initially arriving to a home:

1) Allow Navajo Liaison/ HOA Liaison to greet family and introduce the process which was about to take place. To ensure the maximum comfort of the homeowner, students were instructed to remain inside their vehicle until given the thumbs up. This allowed some time for us internally to begin preliminary discussions on our ladder setup location, finding south solar orientation, and our panel placement.
2) Once given the thumbs up to proceed with the installation, install teams began their setup of taking down equipment and pack outs, mobilizing equipment based on exterior and interior compartments. Groups then began putting on PPE before beginning any interior or exterior work.
3) The exterior group began assessing the roof conditions – areas where the ladder could be clamped and placed for stability, the safety of walking on the roof, and analyzing the roof type to determine the appropriate nail to be used for the solar panels. Before heading up to the roof, if not prefabricated already, the solar panel feet needed to be installed using an adjustable wrench with a 10 mm (about 0.39 in) socket bit to remove the original kickstand hardware and install the solar panel feet which allowed us to mount the panels onto the roof.

a. Simultaneously, the interior group began assessing interior conditions – areas for potential battery placement, wall core location to allow for the cable to run, and light management.

4) Once initial assessments were made, a huddle was held between interior and exterior teams to determine first and foremost where the battery would be placed on the interior. The placement of the PV panels was directly impacted by the battery placement; thus, establishing this initial location was a crucial first step because from the battery placement, we had 30' of cable run to have going through the wall coring and up to the roof connecting the 4 panels.

5) Once battery location was determined, interior and exterior teams broke out to complete their tasks
   a. The Exterior Team began ladder setup with ladder clamps to ensure safety. Since panel layout and orientation was coordinated in the car, this step was just a matter of installation practices being fulfilled with safety and wire management implemented. Communicating with each other, the exterior members coordinated their own installation processes on a case-by-case basis (i.e., how many panels to carry to the roof at a time, where to place them, etc.). Before drilling the panels in, butyl caulk was placed on the bottom of the solar panel feet to ensure roof punctures were sealed. Once panels were in correct placement, the impact driver was used to screw in either 2 ½ in. GRK screws in areas where a roofing stud would be hit, or a 1 ½ in. GRK screws in all other areas. Keeping in mind an aesthetic look, cord organization was essential to make the connection to our 4-branch adapter which connected the 4 solar panels to the main battery cable. Zip ties were used here to minimize movement of cables and reduce slack. The roof team had to be weary when dropping down the main cable towards the core to reduce the possibility of rubbing against any roof sharp edges.
   b. Interior Team began placement of lighting cables to rout to battery. In doing so, the importance of having material alternatives came into play as interiors differed per house (i.e., command hooks vs screw-in I hooks on a 2x4). The additional interior member worked on the wall core using a 1" auger bit to allow roof cable to run from the exterior to the interior of the home.

6) Following the core into the home, the exterior team coordinated the wire slack with the interior team in assisting with pulling the wire through and installing the interior cable clamps. Simultaneously, the exterior team began their cable organization processes installing their drip loop and utilizing cable clamps to solidify the cable route on the exterior wall. Once completed, the exterior wall was caulked using exterior caulk and covered with a peel and stick waterproofing membrane to provide the homeowners with protection from potential rainwater (Figure 8).

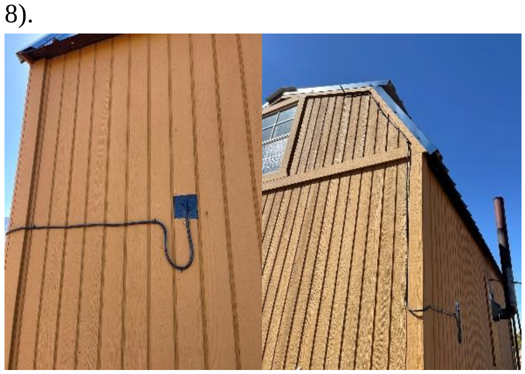

Figure 8. Peel and stick application (Left) and cord management using cable clamps (right)

7) Lastly, the final battery connection is made and remaining punch list items pertaining to housekeeping were completed – this includes removing of tools and trash from the home, repacking the vehicles with all tools, and the systems training to the owner to now utilize their newly installed system.

Results and Lessons Learned

After gaining more understanding of the Navajo Nation and its communities' struggles, it was with great pride that the interdisciplinary teams could make a significant impact on these families' lives with the project commencing on March 29th, 2023. Teams were able to successfully install solar energy systems for 27 families within the Red Mesa and Chinle school districts, enabling their children with the ability to access light for their everyday needs such as completing homework in the nighttime - an otherwise inconvenient and challenging task to complete. Nonetheless, the planning, coordination, and execution of the project could not have been done successfully without faculty advisors and project sponsors' assistance. Table 2 highlights some strengths and weaknesses pertaining to the project's preparation. Table 3 will indicate recommendations to overcome these weaknesses or other concerns for this project's future implementation.

Table 2

Strengths and Weaknesses regarding logistics, preparation, development

Strengths	• Practice building days were critical to success
	  ○ Team dynamics were a major obstacle the team sought to overcome, and this was the most impactful setting to do so as it built teamwork and communication
	• Utilizing returning members' perspective allowed the team to learn from their lessons and implement any changes
	  ○ (I.e., purchasing materials before travel or safety concerns)
	• Reducing the number of students on an install team down to four (from last year's project) allowed for greater efficiency
	  ○ Smaller groups allowed for more hands-on opportunities
	• Safety was heavily prioritized for the project – no injuries occurred on site

Weaknesses	• Lack of communication with stakeholders limited the amount of known information available to project teams to better prepare internal logistics ○ (I.e., the delayed delivery of the google earth coordinates limited the team's ability to pre-plan more efficiently. • Staggered procurement of materials created some back and forth regarding knowledge of what materials were going to be utilized in the actual installation

Table 3

Recommendations to Future Groups

Project Element	Recommendations

<table>
<tr><td>Pre-Task Planning</td><td>Pre-organize toolboxes in a manner which all team members are aware of
This will minimize on-site mobilization and ensure the installation process is more efficient
Timing building day sessions will observe realistic timeframe to complete installations
An hour was used estimate installations times in the field this year; no time was measured during the practice build days to identify this
Ensure earlier procurement of materials and equipment
Practice build days were completed under the assumption of what materials we will have, not what we had readily available to practice with
Prepare for weather concerns – heavy wind or snow can create safety concerns which can then be pre-planned</td></tr>
<tr><td>Means and Methods</td><td>Prioritize safety – no installation is worth completing under the fear of potential injury
Communication with the team is critical to identify potential lapses in the installation processes
Homeowners sometimes have preferences of where they prefer the system – satisfying their needs should also be a priority (I.e., battery/lighting/coring placement)</td></tr>
</table>

Overall, this experience exemplified the epitome of Cal Poly's "learn by doing" philosophy - working among an interdisciplinary team demonstrated an applicable life lesson in that interdisciplinary projects are crucial to challenging existing obstacles and creating new possibilities, whether that is in our academic careers or our professional careers. This year's project combated last year's baseline implementation to include more reach and greater preparation; thus, the Skip the Grid project will continue to be an opportunity for a group of students with different academic disciplines to refine their problem-solving and collaboration skills. Potential future projects include an improved solar design, greater reach to impact more families, and collaborations with additional stakeholders hoping to make a difference in the Navajo Nation.