Skip the Grid: Restoring Light to the Navajo Nation

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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: Solar, Navajo Nation, Sustainability, Skip the Grid, Light, Power, Electricity, Off Grid

Introduction

The Skip the Grid project is an interdisciplinary student lead outreach project backed by industry leaders to provide power and light to homes in the Navajo Nation. The 2023 team installed 27 systems with the help of Heart of American (HOA), and financially supported by SOLV Energy, Goal Zero, Anvil Builders and Cupertino Electric Inc. Skip the Grid was started to make a life changing difference to household be with a free and reliable source of energy. Although the installation of this project took three days to install, there were months of preparation in order to make this project successful. Alongside the successful installations, a refined tool list, safety plan, means and methods, logistics plan, and cultural training background were updated to accommodate a team twice as large
as skip the grid 2022. Ultimately these deliverables were curtailed for all 5 teams to perform efficiently. I was responsible for the tools and materials list for all the teams to base their installation off.

**Background**

The Navajo nation is the largest native American reservation in the United States. The territory of the Navajo Nation spans between New Mexico, Arizona, and Utah spanning over 17 million acers. Although the territory is in the boundaries of the United States the Navajo nation is recognized as a sovereign nation to govern themselves. There are currently 173,000 residents in the Navajo nation. Many households are relying on kerosene lamps or ambient light from wood stove heaters for light after dark. These families also are depending on generators and car batteries as a main power source of they can afford to do so. This is such a huge financial barrier for families to be supplied power by the governing power company. Although the families would be connected to the grid, it would be met with an annual burden of paying for power. During Covid 19, educational disparities were brought to light as distance learning began to take effect while families were unfit with a power supply to charge laptops and Wi-Fi routers. Seeing this need, Heart of America (HOA), a non-profit group focused on education outreach partnered with Mylo Fowler, a native to the Navajo nation, and SOLV Energy to address the problem through off the grid solar systems. This partnership inspired Cal Poly students to partner alongside these companies and together take part in making a brighter future for the next generation of the Navajo Nation.

![Map of the Navajo Nation](image)

Figure 1. Map of the Navajo Nation in relation to the geographical location of the United States

Personally, when I heard about the incredible outreach opportunity happening with in the construction management department, I hopped on the opportunity immediately. Knowing that I had experience in
installing solar systems and having a large array of hand on construction experience I saw myself as an asset to the project. Before hearing of this project, I had previously set up a solar system to my travel trailer that I live out of while attending Cal Poly. The set up required that I understand solar orientation, how an inverter works to harness to then convert solar energy into usable energy, and further widen my wiring experience though use of proprietary connections. Past classes that aided the installation process were CM 214, ARCE 212, CM 313, and CM 413. CM 214 is a residential construction which gave me insight of how houses are built and what it looks like behind exterior sheathing and drywall. This was useful for the installation with the knowledge gained from ARCE 212 since I knew where roof joists were and if there were enough structural support to hold my weight during installation. This also included the stresses that would be introduced to the structure given the load of the solar panels and forces due to lift since the plains and plateaus of Arizona desert regularly have strong winds all year round. CM 313 was Commercial construction Management in which we covered analysis of scopes of work and logistics plans. Since I was responsible for the tools and materials list for the installation process, I relied heavily on the knowledge gained from this class since I needed to account for any gaps in work, lack of tools, and improvement of material used to increase efficiency from last year’s group. I also relied on knowing how to write a post task report for this senior project as it records what work was done exactly as a result of the project. Finally, was CM 413 where jobsite safety was a big focus. Safety on a jobsite is always the first priority and is never taken lightly. Since installation of solar panels were done on the roof tops of these dwellings ladder safety was and roof installation procedures were always followed. All this past experience was used throughout the planning and installation of the systems.

**Process**

**Organization**

The first team meeting was held right at the start of winter quarter 2023. This meeting consisted of team member introductions and project overview led by team leader Heather Sailor, a returning member from Skip the Grid 2022. Introduction to faculty members Jeong Woo, Joseph Cleary and Jacques Belanger were important since they were also returning for a second year guiding the teams along the way and acting as dependable resources though the whole project. There were several areas of need in which team members volunteered to participate in. The main five were the construction team, education, cultural training, fundraising, and systems testing. Each one of these areas played a crucial role leading up to the installation day. as an entire team, weekly meetings were held on Tuesdays as well as weekly meetings that individuals scheduled at their own time. On top of the 5 main groups, volunteers for driving, and roof installation were agreed upon.

**Planning**

The first milestone that had to be met was the cultural training team. They were tasked with researching the history of the Navajo nation and where they are today. This brought to light that the current situation and geological location was a result of the United States expanding west in the early mid 1800’s. this cultural training was held on campus and accompanied by members of HOA, SOLV, and Mylo. This briefing gave not only historical context but also gave Cal Poly students insight into the Navajo’s spiritual belief that we did not want to undermine. Mylo was able to share his experience of living in the Navajo nation in poor living conditions which added to the seriousness of the issue and importance to the project as a whole.
The second team to complete their role was the fund-raising team. Knowing that there is a strong relationship between the Construction management (CM) department, group members worked with CM department head Jeong Woo to reach out to industry leaders for support of the project. Fundraiser outreach was also sent to wood stocks pizza where a percentage of all sales were donated to Skip the Grid. This fundraiser was also among the best team building days as a majority of the team members were able to attend the dinner.

The systems testing team, led mostly by mechanical engineers (ME) and facilitated by ME professor Jacques Belanger, were tasked with familiarizing themselves with Goal Zero’s system and understanding how it works. The system can be split into 3 parts, the solar panel, the battery, and the lights. This team had to understand the optimal direction and orientation for the solar panels for the battery to receive a complete charge within a day of usage. Understanding that the four 100-watt panels would be suitable for the battery was important because we would not want to install an insufficient system. The battery, 1000x, was also tested to inquire about the maximum load it can handle. This included computers, small refrigerators, phones, and other small appliances. The lights were one of those systems. Having a low and high output option from 1 watt to 5 watts allowed the system to support the lights for 200 hr. at 5 watts which output 350 lumens. The most important deliverable from the systems and testing team was the owner’s manual that was created from scratch (see Figure 2). This half sheet was created diagrammatically to overcome the language barrier between English to Navajo. The owner’s manual provides clear instruction for trouble shooting so that nearly anyone can understand how to operate the system.

![Figure 2. Example of Systems Owner Manual](image)

The education team worked closely alongside Heart of American to work on a curriculum to engage students at the Red Mesa school district. The education team wanted to show the next generation of
the Navajo what solar energy is and how it can be used. They built solar powered cars and ran on solar electricity and the students loved it. The students ages ranged from elementary to high school where seniors were able to have a hands-on experience in hopes to spark some interest in the electrical field and potentially go to college with a goal or know that there is a large demand for labor on the solar industry. This curriculum was versatile and was a way to further engage with the community.

Finally, the construction team was responsible for the safety plan, means /methods, and tools/ materials. The construction team was facilitated by CM professor Joseph Cleary who gave valuable insight throughout the entirety of the project. We started off by assessing materials that we had on hand from the year before. This assessment showed that there were tools that were bought and used from the year before. This was a good start and experience was very helpful in refining what exactly was needed. I was responsible for creating an excel spreadsheet of the tool list. On top of modifying the tool list, 3 whole sets of tools had to be purchased to create 5 tool sets. The evolution of the list became better through practice build days and going thorough means and methods that was led by Esteban Hurtado. I was also responsible for selecting suitable tool cases to ensure the safety of the investment of tools and ease of transportation. This tools list is the final iteration as there were no scope gaps during the installation of the systems. Extra small parts were included to prevent a negative impact on lost pieces. The most important activity on behalf of the construction team was scheduling practice build days. The skip the grid team practiced in the SST lab using one of the CM 214 sheds (Figure 3). With Professors Cleary’s experience and supervision, practice build days were held to train teams of the installation process, getting comfortable with tools, and most importantly, identify and prevent out safety hazards. The safety plan was covered by Esai Contreras. Ladder safety straps, appropriate ladder type and type 2 helmets were bought to prevent injury and aide in proper safety practices.

Figure 3. One of many practices build day sessions. (Average installation time 1hr 30 min)
Logistics

Logistics were covered by both Gina Chun and Heather Sailor. They both handled ordering of tools for each team, shipping ladder to Red Mesa school district, and arranging traveling plans. Ladders had to be shipped early to ensure they arrived on time and to eliminate the hurdles while traveling. All tools were ordered off the excel sheet I created with embedded links. Logistics played a huge role as this team had to look weeks ahead of schedule to prevent any setbacks or complications. Logistics also made sure every group was on track with their deliverables and that travel plans were finalized. Another logistical obstacle was setting up members for the 5 teams. Many things like personality types, skill and experience were many factors when creating teams. There were 5 members per team, each with a specified role according to what portion of preparation individuals volunteered for. Team of the 5 teams had a person responsible for supervision, installation of panels on roof, solar orientation mount assembly, and system training.

Traveling to the Navajo nation started March 26th by arriving at the San Luis Obispo airport at 4am to take off and arrive in Phoenix AZ around 8am. From there each team received their rental vehicle and headed to our hotel in Bluff UT. On the way, each team was able to bond over a 10-hr. drive though conversation and music. Once we arrived at around 8pm, we were finally able to meet members of HOA and SOLV where we were briefed about the plan for the following morning. There was a total of 3 build days and after days, see execution for build day details. Now that all the installations were complete, it was time to head back home. Leaving Bluff at 5 am on March 30th, this gave us the opportunity to touch ground at 4pm. At the time, I thought the whole project was complete but then we had dinner with friends and family on May 18. HOA and SOLV were in attendance, so it was nice to see familiar faces again. This dinner was held to celebrate the completion of the project as well as gain interest in the project for the following year.

Execution

Day 1

Waking up bright and early, the education team went with HOA to Red Mesa (see figure.1) to present their curriculum to the students. While the rest of the team prepped for installation. Team leads, who were simultaneously senior project participants and solar panel installers, split off to prep toolboxes while everyone else started to prep solar panels and organize system components. Toolboxes were organized according to indoor and outdoor installation processes. After all materials were sorted, teas were paired up and headed to their first install. We were paired with team blue and to limit misplacing each other’s tools, we used their toolbox for the installation. Sharing the tools among both teams did not pose any issues. This hogan (cultural dwelling with 6 to 8 exterior walls) was good for practice since it was structurally sound, and there were exposed joists to ensure panels were properly fastened (see figure 4). Together we completed the installation in 1hr and 30 min. All installations followed the same procedures.

At arrival on the site, we waited for the community liaison to introduce us to the family and have permission to follow through with the installation. Finding the solar orientation was the first step to optimize the solar panel’s exposer to direct sunlight year-round. Then the interior team asked for the owner’s preference on where they would like the battery and lights to be set up. Meanwhile the exterior team started prepping the solar panels with the roof mounts. As one person prepped the panels The panel installer that was comfortable with being on the roof secured the later to the house using ladder straps. At this point the interior team and exterior team coordinated where the optimal
location was for the harness to penetrate the exterior envelope of the dwelling. Solar panels were then carried on the roof and butyl caulk were placed on the bottom of the mounts and then fastened (see figure 10 for example of roof tools and material). The harness (see figure 6) was then connected, and cable exposer was minimized through zip ties. The structural member of the home. While the exterior team neatly ran the harness along the exterior wall with cable clips and drip loop was made (see figure 10), the interior team ran the lights though the home. Once the system was connected and verified that the battery was charging and outputting appropriately, the hole was sealed with exterior caulking and weatherproof tape was put so to prevent exterior weather conditions from entering the home. While the exterior team packed up the tools and ladder, the interior team trained the homeowner about the system and troubleshooting procedures using the created half sheet. The number of a local community liaison was left if there was any problem with the system. After we dismissed ourselves from the family, it was on the next installation. This practice installation took about 1 hour 30 min.

Day 2

Day two started bright and early with heading to Red Mesa school district to pick up the solar panels and battery systems we were going to need for the day. From the school district we drove to install the homes. These homes were located on dirt roads and isolated from one another. The longest drive required 45 minutes of travel on rough dirt road completely depending on the liaisons of the locations you learn by experience since there are no road names or addresses.

Figure 5. House 2- Due to the orientation of the home not having a south facing wall, two panels were installed on the east and west side of the roof. This allowed the panels to be exposed to sunlight as early as daybreak and as late as night fall. (Installation time 1hr 10 min.)
Figure 6: House 3 – orientation of the solar panels were staked vertically because it was easier to install after marking jist on exposed overhang. (Installation time 1 hr)

Figure 7: House 4 – This home was the home of the grandfather of the community liaison. Same as house 2, the house orientation indicated that 2 solar panels were to be placed on each side of the roof.
Figure 8: House 5 – panels were installed on the southernmost side of this hogan. To prevent the need to penetrate the building envelope, we used an existing opening that the homeowner had created in the past. To prevent wire damage, we filed down any rough edges and reinforced the wire with tape. (Installation time 45)

Day 3

Figure 9: House 6 – This hogan was a special case as this was a hogan that Skip the Grid 2022 had installed the system but at request of the owners and lack of structural integrity, panels were placed on the pallets so solar panels could be put away to prevent damage. The owner was having trouble with intermittent charging and dogs interfering with the wires. As a result, we could not install the solar panels on the roof, so the next best option was installation on the south facing wall. This was difficult due to the struggle of installing panels to structural members on the wall to support the weight. After trouble shooting with a new battery and still observing intermittent charging, a closer inspection of the harness was necessary. Upon inspection, there was a damaged wire that was shorting out the system ever so often due to its position. A new harness was installed the system was working as intended. Extra measures were taken to protect harnesses from any potential damage from dogs. Since the harness entered the dwelling below a hole under the window, a drip loop was not needed. (Installation time 50 min) (Extremely windy)
Figure 10: House 7- This hogan in particular had many obstacles in the way such as an external propane tank, trees on south east side, weak south facing roof and a wood heater on the side, we decided to install the panels on the south west face of the roof as it was the only option that could not safely handle the weight of the panels and myself but also optimize the solar orientation of the panels.

Results

After all the installations, my team delivered 6 new systems and trouble shot an existing system. In total, 27 homes received the Goal zero systems and now have free power. Though out the whole process there were many lessons learned, one of which was the power of interdisciplinary projects. Having 5 of the 6 colleges on Cal Poly represented during the project was a great experience. Although there was a learning curve, it’s hard not to say that the interdisciplinary nature of the project made it more successful than expected. Being patient with non-CM students learning how to build with their hands because the systems testing, education and cultural training would not have been performed at the same caliber compared to how the 2023 team performed. The synergy that came from with team is immersible since everyone carried out all their role with excellence. As a result of this project, the lives of these families and future generations will be changed for the better. Even though most people take for granted the standard commodities of our homes, by merely providing energy and light to these homes, we brought hope to the Navajo nation’s potential to thrive. From this whole experience, the one key lesson I would pass on to future teams would be the importance of communication. With a good rhythm of installation and clear communication between teams, installation didn’t only go smoother and faster but it also encouraged everyone to give their all throughout the project. The tools and materials could be followed exactly according to the excel spreadsheet with no fear of lacking any equipment to address the scope of work or even unforeseen conditions. With the work that was put in to make this project possible, future teams could have an even better jumping off point to continue this movement.