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NAVAJO SOLAR LIGHT PROJECT SUMMARY AND OPERATIONAL REPORT



EAGLE ENERGY



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INTRODUCTION

Background: Elephant & Eagle Energy

Elephant Energy is a non-profit organization based in the United States that seeks to improve the quality of life in developing communities by pioneering ventures that provide access to appropriate sustainable energy technologies (ASETs). Since 2008, the organization has provided ASEts to over two thousand households in the Caprivi Region of Namibia through a variety of market-based mechanisms. Elephant Energy is now in the process of developing a micro-franchise model for the distribution of ASEts in Namibia that provides local entrepreneurs with the tools to market energy products in their rural villages. The first Elephant Energy Shop was established in October 2010, and with its affiliated rural entrepreneurs, provides access to ASEts for the over 70,000 inhabitants of the Caprivi Region, while also serving as a model for Elephant Energy to expand into other areas of rural Namibia.

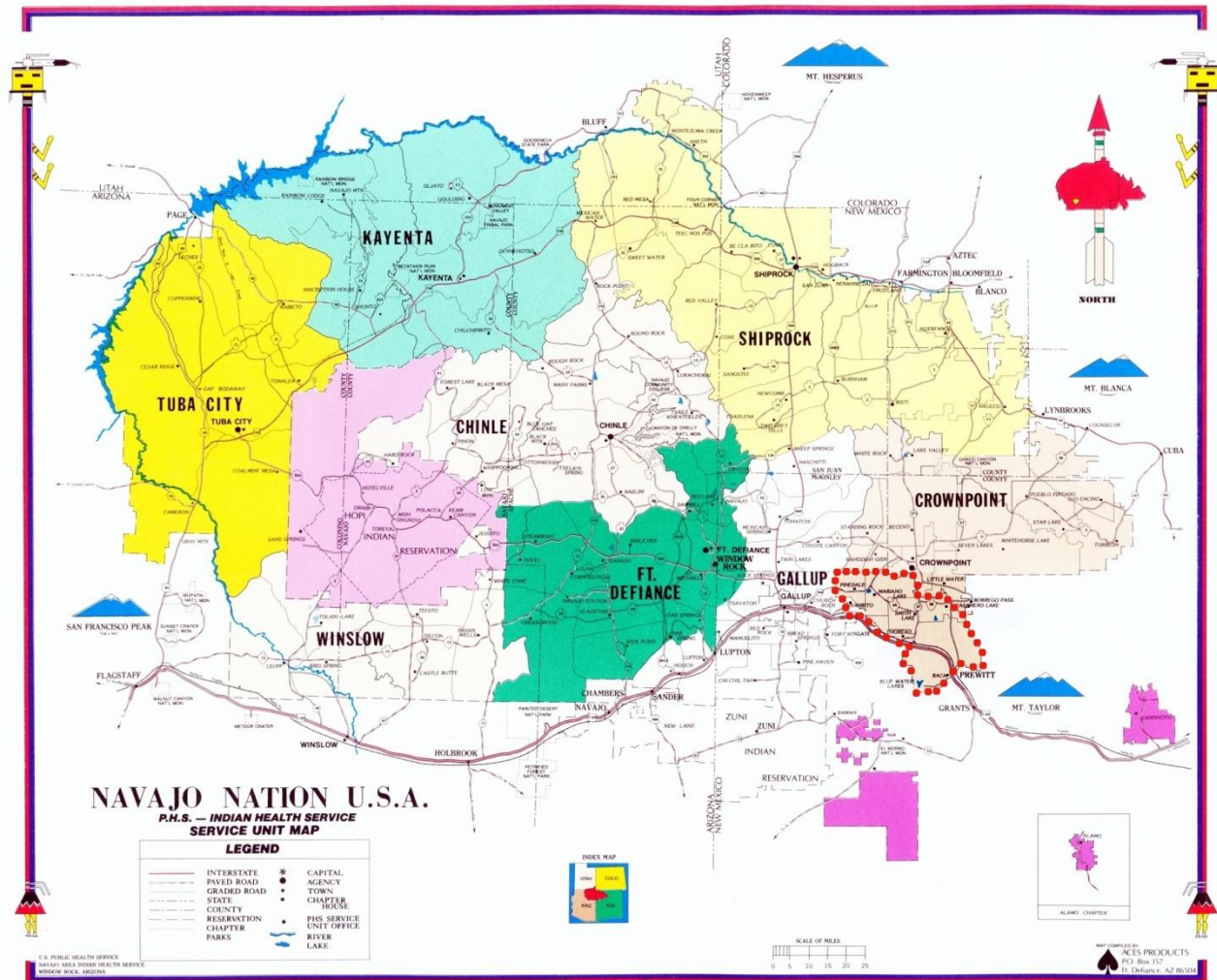
In 2010, Elephant Energy expanded its programs to the Navajo Indian Reservation (Navajo Nation) with the help of a grant from the University of Colorado and support from Dine CARE, a non-profit dedicated to solving energy and environmental issues on the Navajo Nation. The Navajo Solar Light Project involved trips to the Navajo Nation in August, October, and November 2010 by volunteers and students at the University of Colorado Law School to determine whether the ASEts utilized by Elephant Energy were appropriate for use by residents of the Navajo Nation. Initial findings indicate that the 18,000 households on the Navajo Nation that lack access to electricity could greatly benefit from the increased availability of solar-powered lights, such as those that Elephant Energy offers in Namibia, as well as larger-scale solar-powered lighting systems. Elephant Energy has now rebranded for its work on the Navajo Nation, working under the name “Eagle Energy.”

Background: The Navajo Nation

The Navajo Nation is a Native American reservation located in northeastern Arizona, southeastern Utah and northwestern New Mexico. It is divided into five agencies, with eighteen to thirty-one chapters in each agency. It covers a land area of over 26,000 square miles, making it larger than each of the ten smallest U.S. states, with a total population of approximately 180,462 people. Despite being located in the United States, the Navajo Nation suffers from extreme poverty. According to the 2000 census, 42.9 percent of residents of the Navajo Nation live below the poverty level, meaning they had an income of less than \$8,350 per year. This proportion of impoverished people is more than four times the average poverty level in the United States. In addition, 21.4 percent of Navajo families lack plumbing, and 62.6 percent lack basic telephone service.

Navajo Nation Map

- Area of Current Eagle Energy Operation Within Red Dotted Area -



Electricity Issues on the Navajo Nation

In addition to extreme poverty, many Navajo households do not have access to electricity. Although the census does not collect data on household electrification, it is conservatively estimated that around 18,000 of the 48,000 households on the Navajo Nation lack electricity. This poses a number of significant problems for those families without electricity, including lack of access to adequate lighting, heating, and refrigeration. Alternatives to grid-tied electricity, like kerosene for lighting, diesel generation for electricity, and wood stoves for home heating, are often expensive, dangerous, unhealthy, and insufficient. There are many reasons for the lack of access to electricity on the Navajo Nation, including geographic isolation, high poverty levels, and legal and political pressures.

Geographic Issues

One of the main reasons for the lack of access to electricity on the Navajo Nation is the geographic isolation of many chapters, and of individual households within each chapter. The modern electric grid system is designed to efficiently serve large concentrations of people in



populous areas. The Navajo Nation is slightly larger than West Virginia, but has only one-tenth the population spread over the same area. With this many people spread over a vast area, it becomes too expensive to extend power lines between each home. In addition to being geographically isolated, much of the terrain of the Navajo Nation is rugged and without roads. This makes transporting the equipment to build new power lines very difficult, which further increases the cost of installing traditional infrastructure.

Economic Issues

The cost of extending power lines through the rugged terrain of the Navajo Nation is extremely high. The average cost to extend a line a single mile is about \$27,000 and this cost often cannot be split because a line extension may only reach a few new customers. Additionally, despite the large reserves of natural resources for energy production located on the Navajo Nation, the Navajo Tribal Utility Authority (NTUA) does not operate any of its own power plants and is required to purchase electricity from other utility providers. About fifty percent of NTUA's revenues go to purchasing electricity from other suppliers, increasing the cost to its consumers and limiting its funding for new power lines.

Cost is also an issue for households that want to use large-scale photovoltaic systems to generate electricity. Very few households on the Navajo Nation can afford the large up-front cost of a full-scale residential photovoltaic system. The NTUA has a leasing program for two-kilowatt photovoltaic systems, which generate enough electricity to power home lighting, television, and small appliances. The program requires a fifteen-year lease at a rate of \$95 per month, with an \$85 initial fee. However, participation in this program has been low, with only 200 households currently leasing these solar home systems.

Legal/Political Issues

Legal issues have also slowed electricity development on the Navajo Nation. In 1966, a land dispute between the Navajo and Hopi tribes halted all development on over 1.5 million

acres of land in the western portion of the Navajo Nation. The “Bennett Freeze” was enacted to prevent either tribe from taking ownership of the land. During the Freeze, no new housing could be built, no roads or schools could be constructed, and the building of electrical infrastructure was outlawed. Although the Freeze was lifted in 2006, of the 8,000 residents of the area, only ten percent have running water, and only three percent have electricity. The infrastructure needed to run power lines is largely lacking, as are roads needed for new construction. Although a bill was recently put before Congress to create a trust fund to help develop the former Bennett Freeze area, it will be years before the area can reach a level of home electrification even equal to the rest of the Navajo Nation.

Many elderly Navajo have lived their entire lives without electricity, despite promises from the Tribal Government and NTUA. As a result, many people have lost hope that they will ever be provided electricity. One woman interviewed by Eagle Energy volunteers said that the government promised that electricity would arrive by Christmas over 15 years ago and it had still not arrived. Despite a clear wish for electrification, many Navajo communities have no choice but to burn kerosene and wait.

BENEFITS OF SOLAR TECHNOLOGIES

Like Namibia, the Navajo Nation also has world-class solar energy resources, making it an ideal location for solar energy production. Eagle Energy’s small-scale solar technologies are ideal for Navajo Nation residents living in rural areas that are not likely to receive grid electricity in the near future. Eagle Energy is currently distributing six different solar lighting technologies on the Navajo Nation, including the D.Light Kiran, Sun King Lantern, ToughStuff solar panel and light, Nokero solar light bulb and the large and mini BOGO light. All of these technologies use small solar panels to charge rechargeable batteries that power LED bulbs. Some of the lights are designed as flashlights, some as lanterns, and some can also be used to charge cell phones.

These ASETs provide a quality source of lighting, allowing people to work and learn when they previously were forced to live in the dark or pay a high price for illumination via kerosene or propane. At a cost of \$25 to \$35, Eagle Energy’s lights are not much more expensive than a kerosene lantern, and incur no additional monthly cost after purchase. Furthermore, solar technologies provide health benefits by reducing indoor air pollution and help to protect the environment by decreasing greenhouse gas emissions when compared with kerosene use.

Economic Benefits

Cost is also an issue for families that currently have access to grid electricity. With the high poverty levels that exist on the Navajo Nation, many who have access to grid-tied electricity cannot afford their monthly bills. Many Navajo families interviewed by Eagle Energy volunteers expressed an interest in solar-powered lighting technologies as a way to lower their monthly electricity bills. Eagle Energy’s solar-powered lights provide a distinct economic advantage compared to kerosene and propane-fueled lanterns because they do not require users to buy multiple replacement fuel canisters per month. Although solar-powered lights come with rechargeable batteries that must be replaced after one or two years, the \$5 cost is negligible compared to replacement fuel canisters.

Health Benefits

Solar Lanterns also provide a health benefit over the kerosene lanterns commonly used by the Navajo Nation. Although the health impacts caused by using fuel lighting is an understudied field, a recent article in the *International Journal of Indoor Environment and Health* attempted to quantify the risk. The authors found that vendors using simple kerosene lanterns were exposed to particulate matter concentrations significantly greater than the amount present in the ambient air. Such exposure can present long-term health risks. The article concluded that the best solution to combat this problem is the use of solar LED lighting.

Educational and Productivity Benefits

Candles and kerosene lanterns provide a low-quality light source, making it difficult for children to read and do homework, while Eagle Energy's solar technologies provide high-quality light. Providing children with access to sustainable energy technologies is also important, as children will be responsible for making sustainable energy choices in the future. Solar lighting technologies can also provide a benefit to people without electricity who work from home, allowing them to work after dark at a lower cost compared to kerosene lanterns.

CO₂ Emission Benefits

Kerosene lanterns also produce CO₂ emissions, causing harm to the environment. The average kerosene lantern, when used for four hours per night, produces over 100 kilograms of CO₂ emissions per year. If we assume that each of the 18,000 households on the Navajo Nation has just one lantern and uses it for four hours per night, the net greenhouse gas emissions reduction from kerosene lanterns on the Navajo Nation would be over 1.8 million kilograms per year. For reference, this is equal to driving over four million miles in the average car. Replacing these lanterns with solar-powered lighting technologies would eliminate these harmful emissions.



PROJECT IMPLEMENTATION

Eagle Energy's Navajo Solar Light Project ("Pilot Project") involved three phases. First, Eagle Energy located specific Navajo communities with significant numbers of off-grid households. Second, Eagle Energy surveyed volunteer households from the community about their general energy usage and needs, and distributed a total of 100 solar-powered lights of six different types to volunteer households (two different types to each household). Finally, Eagle Energy followed up with a survey about the participants' use of these technologies. These three

phases roughly correspond with three trips made by Eagle Energy's Colorado-based volunteers, which spanned a three-month period from August to November 2010. During this time, Eagle Energy's locally stationed partner in the Pilot Project, Melton Martinez, also conducted work in the communities with the help of Dine CARE.

Phase I: Locate Communities and Determine Need

In August 2010, volunteers traveled to the Navajo Nation locate suitable partner chapters, and determine whether Eagle Energy's ASETs were appropriate for use on the Navajo Nation. During this trip, Eagle Energy established a partnership with four chapters in the Eastern Agency of the Navajo Nation, including Baca, Thoreau, Pinedale, and Mariano Lake Chapters. These



chapters, located near Thoreau and Grants, New Mexico, were chosen due to previous connections with local community activists in the area and the proximity to Eagle Energy volunteers in Colorado.

Thoreau Chapter: According to the 2000 census, Thoreau chapter had 1,450 residents living in 415 households. The median household income was \$22,366, with one-third of all families below the poverty line. Nearly 50 percent of families lacked telephone service, and 64 percent used wood for home heating.

Baca Chapter: In 2000, Baca chapter had 889 members living in 206 households. 44.5 percent of families lived below the poverty line, with a median household income of \$17,708. Over 68 percent of families use wood for home heating, and 49.1 percent lacked telephone service.

Pinedale Chapter: In 2000, Pinedale chapter had 1,129 residents living in 293 households. Over 48 percent of families lived below the poverty line, with a median income of \$13,040. 77 percent of families used wood for heating fuel, and seventy-two percent lacked telephone service.

Mariano Lake Chapter: According to the 2000 census, Mariano Lake had 870 families in 260 households. The median household income was \$10,625, with 40 percent of families living below the poverty line. More than 73 percent of families used wood for heating fuel and 68.8

During meetings and home visits, participants were very supportive of the idea of increasing access to small-scale solar technologies. Participants noted that many Navajo people are without access to electricity, and that other forms of lighting, including kerosene and propane lanterns, flashlights, and car battery-charged lights, are either expensive, dangerous, or both. Participants also noted that even those with access to electricity might benefit from solar lights because it could help reduce their electricity costs.

Phase II: Survey Households on General Energy Use and Distribute Solar Lights

Eagle Energy organized a second trip to the Navajo Nation in October 2010 after confirming that small-scale solar technologies would address real energy needs in the area. The purpose of this trip was to gather specific data on the energy needs of the communities and distribute a small batch of solar-powered lights.

During this trip, Eagle Energy conducted three separate public meetings at the Thoreau, Baca and Pinedale chapter houses. At these meetings, Eagle Energy distributed solar-powered lights and administered surveys to measure the energy uses and needs of Navajo people. Eagle Energy representatives made clear that they would be conducting a follow-up visit roughly a month later to gather survey data from participating households.



The first survey was designed to obtain baseline data. It was conducted when the lights were distributed, and consisted of ten questions regarding each household's general energy use and needs beyond lighting. The baseline energy use survey also asked for more specific information about household members, including number of people living in the household, their ages, and other demographic information. This survey was written in English, although Eagle Energy provided translation to those who felt more comfortable communicating in Navajo. Overall, Eagle Energy gathered baseline energy use surveys from twenty-nine households. All participants who filled out a general energy use survey were given lights, making the total number of distributed lights during the trip fifty-eight. At the conclusion of the trip, the remaining lights (forty-two total) were given to Mr. Martinez to distribute.

Phase III: Follow-up Trip and Survey on Solar Light Use

The main purpose of Eagle Energy's third trip to the Navajo Nation was to collect follow up surveys and meet with some of the families who received lights during Phase II. The results from this trip are discussed below. During this trip, Eagle Energy's resolution for funding solar lights at Pinedale chapter was presented and passed. This resolution demonstrated buy-in from the chapter. Additional resolutions have since been passed in other chapters in the area.

PROJECT RESULTS AND DISCUSSION

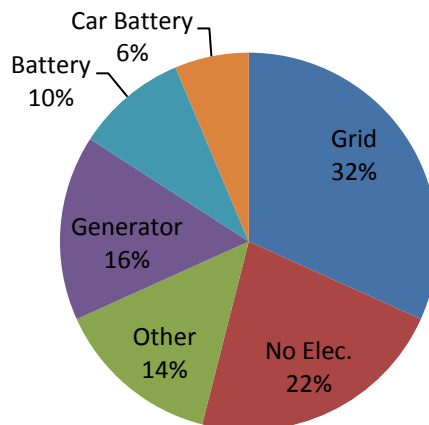
Baseline Energy Use Survey Results

The baseline surveys Eagle Energy collected on the second trip illustrate the energy needs and usage of families in rural areas on the Navajo Nation. These surveys also recorded

information about the energy sources used for specific activities, as well as the average amount spent on varying energy sources per month.

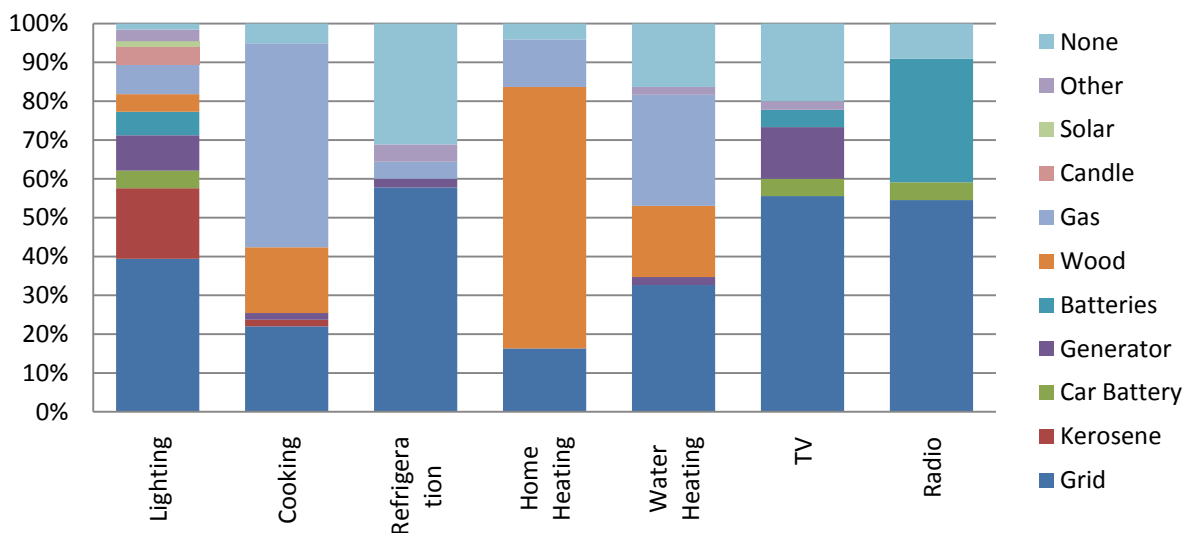
The baseline survey illustrated the severe lack of access to electricity in the four-chapter area. Only forty-three percent of the people surveyed had access to grid electricity, thirty-four percent were using generators or batteries, and thirty percent had no access to electricity at all. Table 1.1 shows access to electricity by energy source.

Table 1.1: Electricity Sources



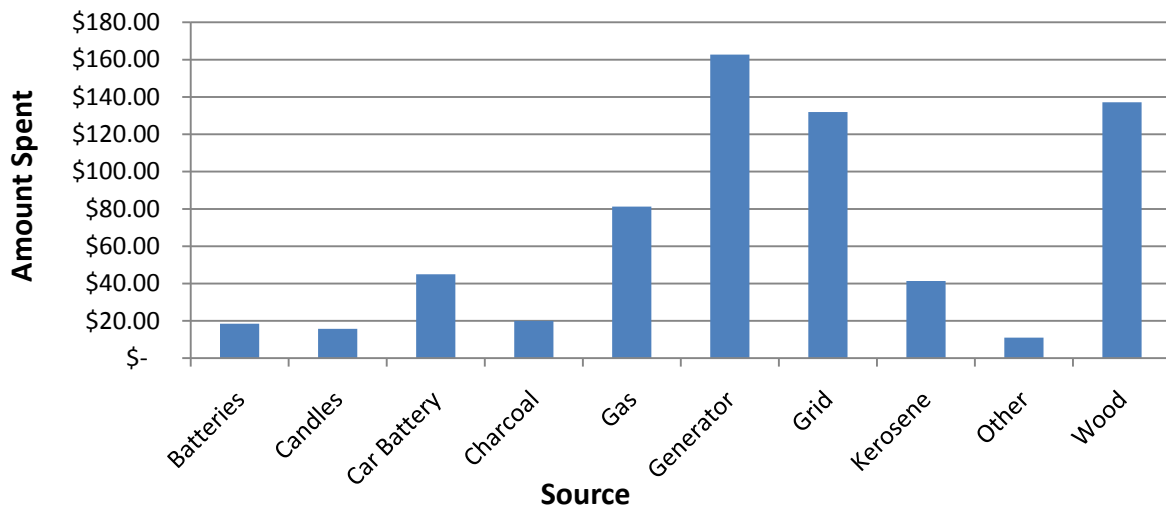
The baseline energy use survey also recorded the activities performed with each source of electricity. Table 1.2 shows the sources of electricity for each of these uses.

Table 1.2: Energy Sources Used for Different Activities



In addition, the baseline survey recorded the average amount spent on different energy sources per month. Table 1.3 shows the average spent per household during the month prior to filling out the survey in October and November 2010.

Table 1.3:
Average Amount Spent on Different Energy Sources



Follow-Up Survey Results

Pilot Project participants used six varieties of Eagle Energy’s solar-powered lights for one month, providing valuable information on the suitability of small-scale solar lighting technologies on the Navajo Nation by filling out follow-up surveys. Participants found many uses for the lights, including some tasks that were impossible to complete with the limited array of energy products currently available on the Navajo Nation. Table 2.1 represents the activities that each solar-powered light was used for, and table 2.2 shows the tasks the lights made possible that were not previously possible.

Table 2.1: Uses of Solar Lights

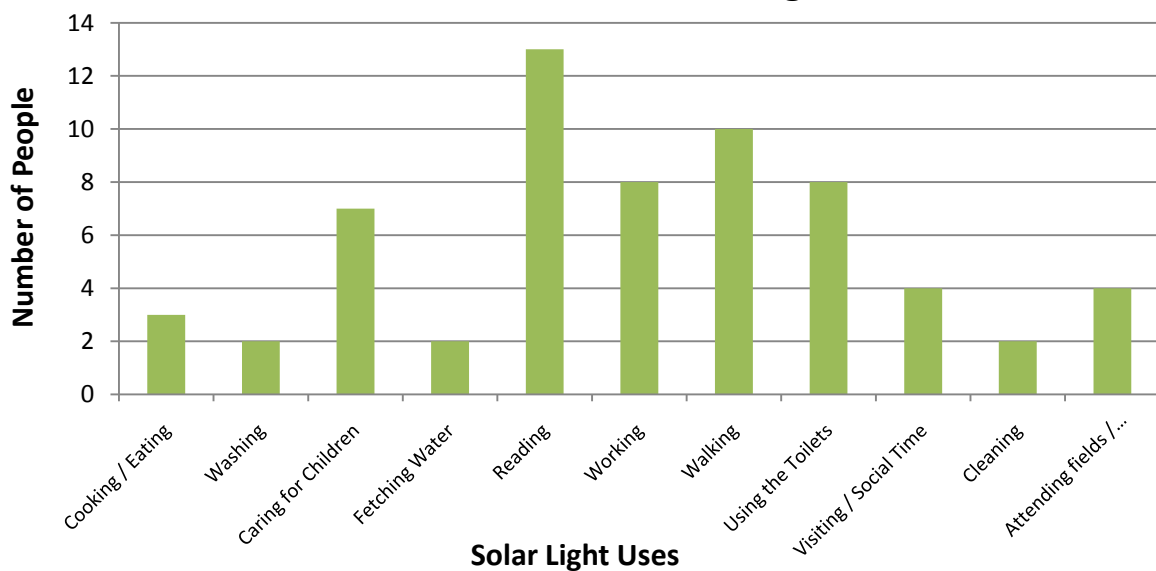
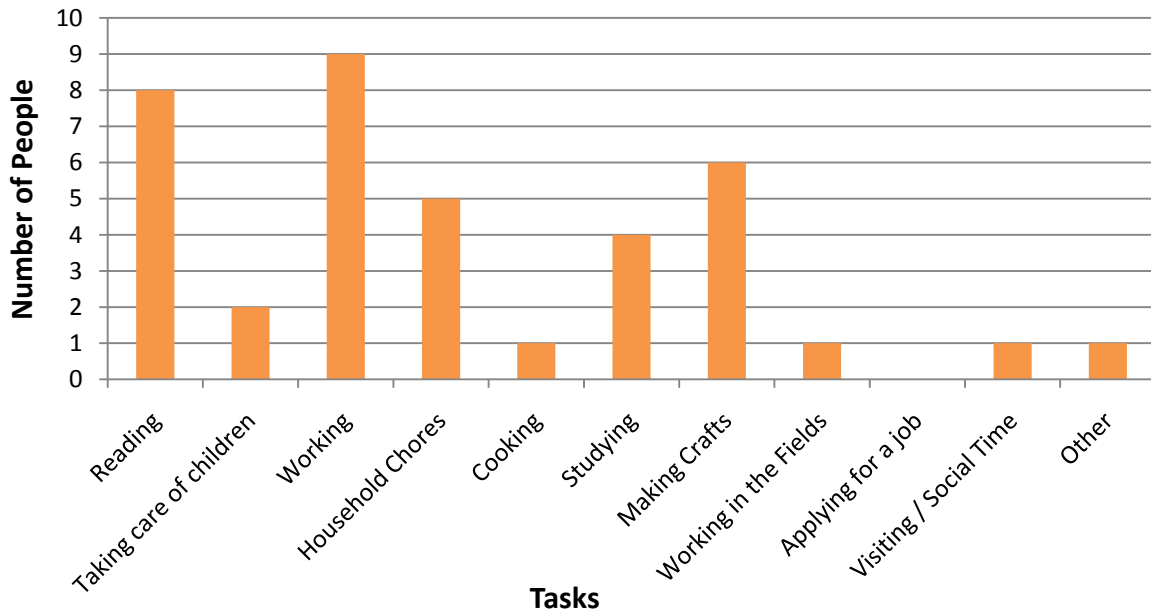
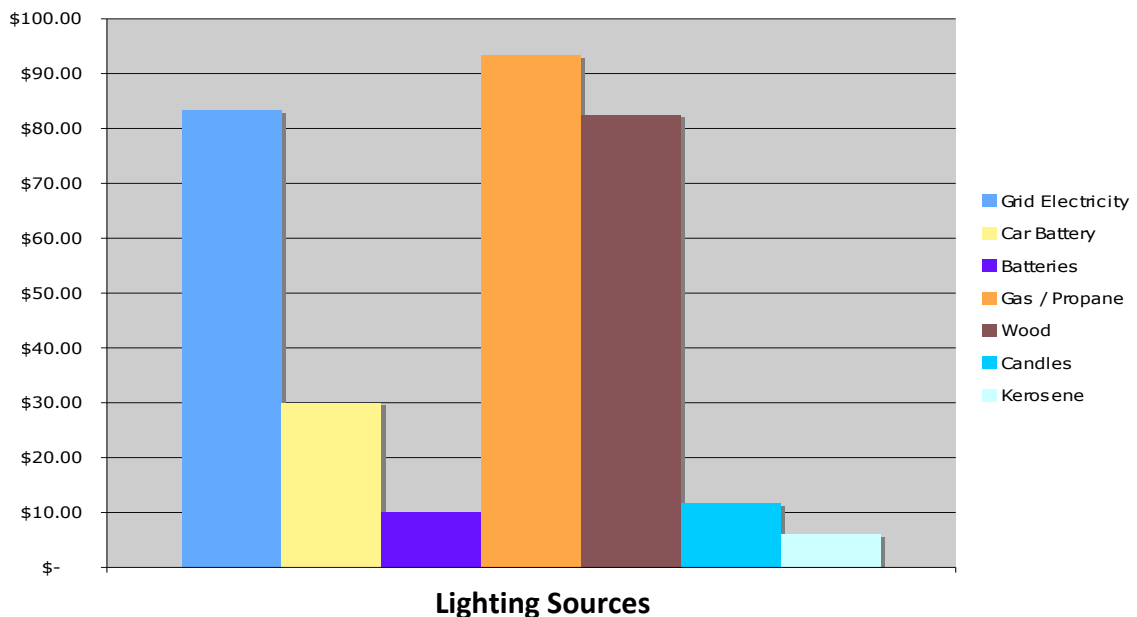


Table 2.2: Tasks Solar Light Made Possible

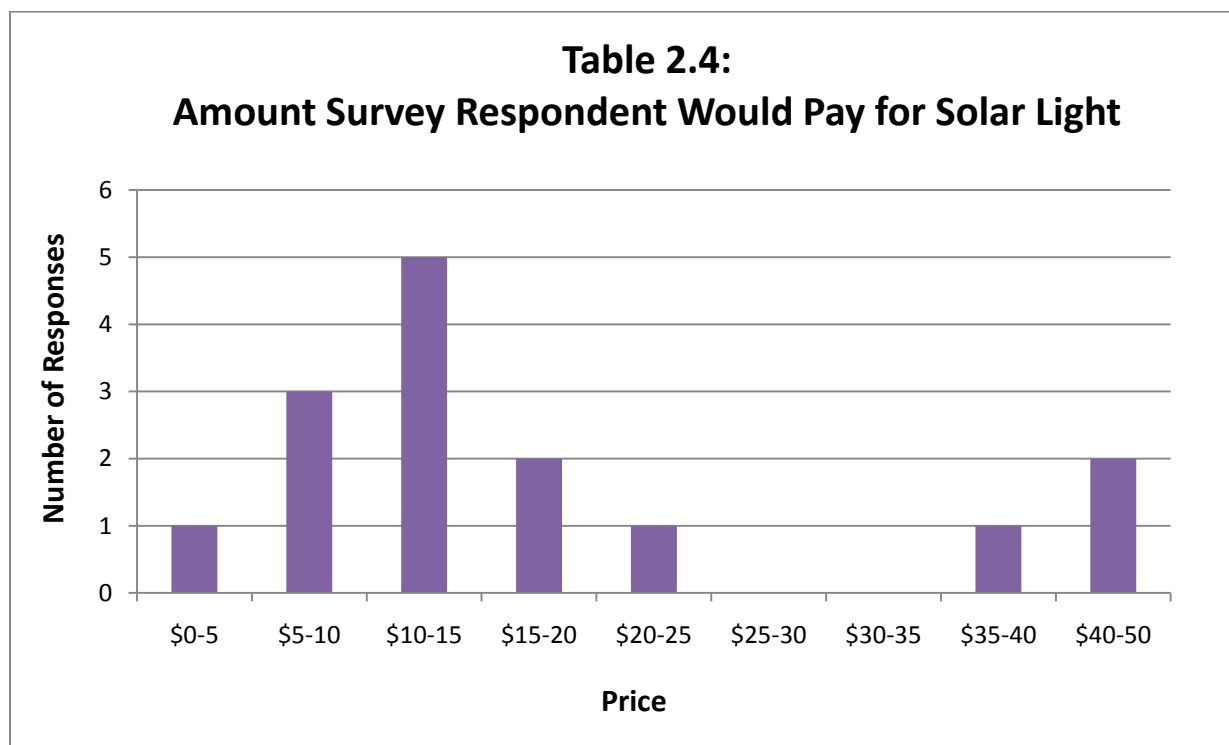


The follow-up survey also showed the economic benefits of Eagle Energy’s solar lighting technologies. The survey respondents reported the amount of money they spent on lighting and the amount the solar lights saved them during a one-month period. Table 2.3 shows the average amount of money spent on various lighting products during the month before using solar lights. After using the lights, users reported an average savings of \$36.88 for the month.

Table 2.3: Average Amount Spent on Light Sources



The surveys also showed that the solar-powered lights provided by Eagle Energy are quality products that are appropriate for the Navajo Nation. The survey respondents all found the lights very easy to use, and all of the lights worked properly over the course of the pilot project. The Pilot Project participants expressed an interest in paying for more lights in the future, with an average response of about \$15 being the price that people would be willing to pay. Table 2.4 shows the amounts people said they would be willing to pay to purchase these lights.



Pilot Project Data Analysis

The results of the baseline and follow-up surveys make several points clear. First, there continues to be a severe lack of access to electricity in the southeast corner of the Navajo Nation. Most Navajo families surveyed used a mix of fuels to meet their daily energy needs, instead of relying on a gas line and electricity, as is common elsewhere in the United States. These sources of energy are extremely expensive, costing families far more per month than they would spend to receive a similar amount of energy through an electric line. Many Navajo families rely on car batteries or generators to run lights and appliances. Other households do not have access to batteries or generators and must make do with zero electricity while paying high prices for kerosene, propane, and wood to meet their energy needs.

Second, the surveys show that Eagle Energy's small-scale solar-powered lighting technologies are appropriate for use on the Navajo Nation and can make a difference in people's lives. All survey respondents found uses for the light as a replacement for their customary lighting products, like candles, kerosene, and propane. Many respondents were also able to accomplish tasks that were impossible with other forms of lighting. For example, one respondent said the solar light allowed him to continue his welding business after dark because he no longer

had to use his generator for lighting. Another respondent said she was able to continue her intricate beadwork at night due to the higher quality light provided by the solar lantern. In addition, many respondents commented on the quality and ease of use of the solar lights.

Finally, the surveys show that it makes economic sense to offer small-scale solar-powered lights for sale on the Navajo Nation. The large amount spent on inefficient and poor quality lighting products and fuels, such as kerosene and propane lanterns, makes it clear that \$25 to \$35 solar-powered lights are a cost effective alternative. In addition, people expressed a willingness to pay the higher up-front cost for a solar-powered light in order to avoid continuously paying for kerosene, propane, and batteries.

CONCLUSIONS AND FUTURE PLANNING

It is clear from the results of the Pilot Project that there remains a lack of access to electricity on the Navajo Nation, and that Eagle Energy's ASETs can be used to meet the energy needs of Navajo families at a basic level. In preparation for project expansion, Eagle Energy must set goals, study distribution strategies, strengthen and expand partnerships, and increase marketing and outreach efforts.

Eagle Energy must determine which ASETs are best suited to meet the energy needs of the rural Navajo people. Although all of the tested solar-powered lights were useful, other technologies may be more appropriate, including: brighter solar-powered lights, larger solar home systems, efficient cookstoves, portable solar chargers, and other ASETs.

Going forward, Eagle Energy must continue to ensure that its partner chapters buy into its mission. Passing chapter resolutions is an important first step in community involvement, but additional relationships with community leaders and other local Navajo organizations must be formed if Eagle Energy is to have an enduring impact on the Navajo Nation.

While giving away solar-powered lights was necessary to gather data during the Pilot Project, Eagle Energy does not plan to give solar-powered lights away in the future. Similar to work under the "Elephant Energy" brand in Namibia, Eagle Energy plans to conduct a feasibility/market study to determine if a market-based distribution model for small-scale solar-powered lights is economically viable, including sales via swap markets, established shops, rural salespeople, mail orders, chapter house sales, etc. Using market-based distribution will allow Eagle Energy to more effectively distribute solar technologies, while also creating jobs on the Navajo Nation.

Although market-based product distribution is preferred, many elderly Navajo people have very little money and could be difficult to reach via a sales model. As a result, Eagle Energy plans to continue to work with the Baca, Pinedale, Mariano Lake and Thoreau Chapters to purchase a stock of solar-powered lights for distribution. Subsidized or free lights should only be available through the Chapters for the elderly and sick.

Eagle Energy also plans to continue its strong outreach efforts by partnering with local schools and community groups on the Navajo Nation. Eagle Energy volunteers will develop educational materials and strategies to inform Navajo people about the benefits of renewable energy, especially the economic benefits of using solar-powered lights instead of expensive kerosene, propane, and batteries.

Finally, the Eagle Energy team ends 2010 with an ambitious goal to eradicate kerosene use on the Navajo Nation in the next five years with the help of their Navajo partners. In 2010, Eagle Energy demonstrated the \$25 solar-powered alternative to the \$25,000 power line. In 2011, Eagle Energy will continue to work to bring light to the 18,000 families on the Navajo Nation without electricity and provide them with the technology many Americans take for granted.

