Status and Outcomes of PV Systems in Rural Nicaragua

by

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1.0 Abstract

Every day most of the world turns on their computers, their phones, their lights, and takes for granted having access to electricity 24/7. For over 1.2 billion people living in energy poverty, this isn't the case. A variety of organizations from governments to non-profits are working to alleviate this issue, one of which is North Carolina native non-profit, United Solar Initiative (USI). USI, founded in 2014, has been working to empower communities in underprivileged communities in Nicaragua through solar energy solutions. This study looks at 5 specific projects completed by USI over the last several years, comparing their design rationale to the project outcomes, and looking for ways to improve photovoltaic solar installations in the developing world. Specifically, we will delve into installation issues, differences between the design of the systems and their current use, and monitoring procedures to ensure project longevity. A survey was conducted using past USI monitoring experiences and lessons learned from literature to examine user experiences and the long term sustainability of the projects. The goal of this study is to find ways that United Solar Initiative can improve as an organization to make a greater impact on the communities they work in.

2.0 Introduction

In the United States we are constantly pursuing a better life, we work, we move, we constantly do what we can to improve our standard of living. There are many drivers behind economic growth and general improvements in standard of living, however, not having energy available has left much of the developing world in the dark. It is currently estimated that over 1.2 billion people worldwide live without access to electricity, predominantly in rural areas [1]. The International Energy Agency projects that over 1 billion people will still lack access to electricity in 2030.

The importance of increasing access to energy has been well studied. A report from the Department of International Development highlights the significance of energy in achieving the eight Millennium Development Goals laid out by the UN [5]. Some of the most important uses for energy include cooking and lighting [3,4]. Impoverished populations have little to no choice when it comes to how they can light their homes, schools, etc., unfortunately using costly and/or harmful methods including burning biomass, kerosene lamps, batteries, and fossil fuel generators. Burning biomass in home or producing light from a kerosene lamp increases indoor air pollution and has been linked to higher levels of respiratory illness [17], up to 70 times more so than the equivalent light from the grid, while also producing toxic gasses. In addition to health benefits, gaining access to a stable form of electricity improves people's lives in a myriad of ways. Productivity and small business are allowed to grow by extending the workday with lighting, and freeing up time through mechanizing a variety of processes, such as grinding coffee beans. Education is enhanced with access to electricity that provides lighting for studying at night, and opens the door for a multitude of learning materials, including the radio, computers, and the internet. Energy services empower people by increasing literacy rates and provide a path out of poverty by creating opportunities for income-generating activities and access to new forms of communication.

This paper will focus on the technologies and organizations providing electricity in the developing world, specifically how to improve the work being done with photovoltaic solar system installations. Objectives and areas of study include common installation issues, system design compared to system use, and monitoring and evaluation procedures which ensure longevity of project installations. United Solar Initiative has consented to the use of several of their past installations to be a case study for this research. This research will analyze literature and past USI projects to investigate the design process and rationale for providing photovoltaic systems in the developing world. including the system designs compared to the needs of the community. Specifically, the load assessments off the site, bills of materials, and system designs will all be analyzed and compared to the intentions and outcomes of the projects. A survey will be prepared and conducted with USI clients to look at the current status and use of the systems as well as user experiences in order to analyze potential improvements to the process as a whole.

3.0 Literature Review

In order to understand how best to approach the issue of access to electricity for over a billion people, it is important to understand why there is such a large problem. Providing people with a reliable source of energy is an expensive undertaking. We often take our electrical grid in developed countries for granted, not realizing how difficult this can be to develop without access to stable financing. In countries across the world that have struggled economically, the grid is severely underdeveloped. Unfortunately, the cost of grid expansion is incredibly capital intensive, and utility companies have no incentive to expand to new areas when sales won’t cover the cost of expansion [8]. Extending the grid to rural households can be 7 times more expensive than similar grid expansion in urban areas [5]. Even in areas where grid access is available, outages can be a daily occurrence due to capacity shortages and poor transmission, among other operational issues [7].

The traditional response has been to attempt to expand centralized, government-owned electric grids into rural areas. This approach may still work in some regions, however, it is likely that the best solution for developing countries is to invest in distributed generation, or on-site electrical production, independent from the grid [9]. In order to develop an economically feasible energy system, developing countries will need to institute a combination of both centralized and distributed sources. Developing countries have the unique opportunity to leapfrog the traditional grid, and transition to a more distributed approach to electrification, especially in rural areas. We can draw a similar comparison to the rapid adoption of the cell phone market in developing countries, allowing these regions to skip the conventional land-line model.

3.1 Biggest needs for electricity

The most basic and immediate electricity demand for consumers is lighting for commercial, health care and household uses. Lighting gives people greater control over their lives, allowing users to perform activities at night and to be more productive during the day. Studies have documented that children with access to distributed generation systems are able to study more, and that shopkeepers are able to stay open later, facilitating business [10]. With the rapid technological advancement of our society today, we have seen an increase in the importance of access to other small-load devices, such as cell-phone charging, radio, and television as well. In many developing areas, people rely on cell phones for communication and payment transactions, but don't have reliable methods to charge them without electricity. Additionally, considering women and girls spend the most time and effort on cooking, collecting water, and other household needs in developing areas; any improvements in energy access allows women to spend less time on household chores and more time on education and income-generating activities [11].

The Human Development Index (HDI) is a composite statistic of life expectancy, education, and income per capita used to rank countries [12]. Literature points to the fact that the positive contribution to the HDI is strongest for the first kilo-watt of energy available, meaning that the poorest benefit greatly from even a small amount of electricity access [4]. This low level of electricity pairs well with off-grid renewable energy technologies. Renewable electricity solutions have been researched and put into place worldwide in order to begin to provide communities with the electricity they need to break out of poverty. Photovoltaic (PV) solar technology was one of the first renewable energy technologies adopted globally as a form of distributed electricity generation. There are four primary driving forces for why PV makes the most sense in developing countries that have been discussed: the *accessibility* of PV in remote locations, the low *load demand* in areas of poverty matches well with the characteristics of PV, electricity being recognized as a key solution in the *fight against poverty,* and the potential for *leapfrogging* the conventional grid system [3].

3.2 History of PV in developing world

PV has been used to combat the lack of rural electrification in the developing world since the 1980s when the global scientific community recognized that the technology was maturing, costs were declining, and there was a market for off-grid applications [4]. Since 1983 half of the houses on the outer islands of Tahiti rely on PV and more rural Kenyans use PV for electricity than grid power [16]. There is a plethora of literature on PV projects in the developing world that have had varying degrees of success and used a variety of strategies and it is instructive to delve into a few specific examples.

Governments have been responsible for a large portion of these PV projects, as can be seen by the joint US-Brazil project in the early 1990s. The US Department of Energy (DOE) partnered with the Brazilian government to install 750 home lighting and 14 larger PV systems in northeast Brazil. The USDOE provided technical assistance for planning, implementation, and monitoring, while local utilities would own, install, and maintain the systems and collect small tariffs from system users. The objective of the project was to "establish and assess the efficiency, operability, and reliability of solar energy-based ruDral electrification." The USDOE committed $855,000 to the project compared to Brazilian parties' $2,067,000. The project could be considered a success, however much can be taken from it regarding long-term goals. Siemens Solar was selected as the sole equipment supplier over the Brazilian manufacturer Heliodinamica, due to the affordability of their modules. Bypassing an indigenous manufacturer that already served local markets caused a stir and was counterproductive to establishing a sustainable project model. Another shortcoming of the project was that the design didn't promote sustainable PV diffusion. End users made no down payment on the system, and paid for little more than operations and maintenance [2].

Another project conducted in the Dominican Republic attempted to address capital and institutional barriers to PV deployment using a nongovernmental organization strategy. In 1984, Enersol Associates Inc., a US-based non-profit, began supporting the development of indigenous Dominican supply and service, and financing a market driven demand for household PV systems [2,14]. Enersol used grant funding to train a network of local entrepreneurs to market, install, and service PV solar systems. They developed a community based NGO to manage loan funds for individual users and helped communities develop full cost-recovery financing of the systems. The goal of this project was to develop an "open-ended self-sustainable program for solar-based rural electrification", and eventually, to integrate solar technologies into the rural communities of Latin America. The program begun in 1985 with 6 systems had reached 1,000 by 1989 and 2,000 by 1993. Fifteen commercial installation businesses, four equipment importers, and two balance-of-system manufacturers now supply the Dominican market. This infrastructure has provided the basis for development of larger community lighting and water pumping systems, as well as self-facilitated home installations. This project shows the value of NGO work that creates sustainable outcomes, something that should be considered by every non-profit organization.

It is important to take the work of other groups into consideration when undertaking a series of projects, especially in the developing world. Literature reveals a myriad of lessons to take away from the past. For example, an analysis of solar home system uses in Zambia revealed that users tend to increase their electricity use in years following the installation, adding more appliances and loads than originally accounted for [13]. The US-Brazil collaborative project showed us that with no down payment on PV systems, the end-users of the system had no sense of ownership, and that if you want to implement a sustainable model you shouldn't outsource materials over local companies [2]. Analysis of these projects reveals that it is important to design a project that encourages sustainability, through developing a sense of ownership, ensuring future funding, etc. after the NGO is done with the project [2,14]. Long term effects of distributed generation products have not been well documented, especially when it comes to health and education [8]. Finally, NGOs often focus too much on the investment phase with no long term plan, and users of the systems lack awareness about its capabilities and limitations, leaving much of the developing world scattered with failed attempts at rural electrification [15].

3.3 United Solar Initiative (USI)

NGOs are, and should be, key players in the efforts for rural electrification, especially in the PV market. United Solar Initiative is a non-profit organization based in Chapel Hill, North Carolina that collaborated on this research to examine system designs and outcomes at an in depth level. USI is a 501c3 organization with the mission to provide a clean and stable source of electricity to undeveloped communities around the world, via solar energy solutions. They strongly believe that distributed energy in the form of PV technology has the potential to help address the global issue of energy poverty. They have completed a series of solar PV projects to electrify schools in rural regions of Nicaragua, working with local NGOs and solar companies as a key strategy. Through an early mentorship from Richard Harkrader, USI was able to partner with Sister Communities of San Ramon (SCSR) and identify a great need in rural Nicaraguan schools without any access to electricity.

USI operates primarily on grant funding and corporate donations, with some key donors including Wells Fargo, Schletter, Strata Solar, and Depcom Power. They use an application and referral process to identify potential sites for an installation. USI also works with local nonprofits, specifically SCSR, to identify potential sites. Sites include schools and community centers in areas with unstable or no access to electricity. Working with local NGOs allows USI to not be as much of an outsider, as they can easily be connected to community leaders to identify the real needs for the project. Once a project has been identified and funding has been secured, USI begins working with local community members for every part of the process. They have partnerships with several local solar companies, including EcoEnergias and SuniSolar, that perform a site and load assessment for schools in collaboration with the community members (principles, teachers, and often parents) to determine the load demand of the site. USI then works with the solar company to design the most appropriate system for each location, and begins preparing for the installation. After installation is complete, USI hosts a training session with the community members that will actively be using the system, informing them of the basic principles behind solar energy and how to troubleshoot the system, or at least tell when something is wrong. In addition, the systems are monitored quarterly to ensure that they are still being used and are working properly.

4.0 Methodology

This research examines five of United Solar Initiatives' projects, from the planning phase through the installation and use phases. This examination is supported by a survey based on hands-on experiences from projects and issues of interest identified in the literature. United Solar Initiative has been compiling information from all of their projects in Nicaragua on Google Drive, allowing information on every project to be easily accessible to anyone within the organization or with proper permission. Through collaboration with USI the following documents were received for each project, and can be found in the appendix.

1. Load assessments
2. System designs by SuniSolar and EcoEnergias
3. Pictures of location
4. Pictures of completed system

4.1 USI Project Descriptions

4.1.1 Arte Movimiento

The Arte Movimiento project is an art school located in San Ramon, Nicaragua. It was one of USI's first projects, and was installed in collaboration with SuniSolar and Appalachian State University. 12 students from Appalachian participated in the installation of this system as a part of their Sustainable Technology curriculum. It is a 240W system consisting of three 80W panels and two 12V 150ah sealed batteries wired in parallel. This project was completed in June of 2014.

4.1.2 San Antonio de Upa

San Antonio de Upa is a school in a small mountainous town in the Matagalpa region of Nicaragua. As with most of USI's projects, the school had no access to electricity prior to the installation of a 200W photovoltaic system. The system was designed using AGM sealed batteries and two 100W solar panels. The project was completed in December 2014 in collaboration with local solar company SuniSolar.

4.1.4 Santa Ana

Santa Ana is United Solar Initiative's most recent installation, a 940W project completed May 2016. This system was designed with four 235W solar panels and four 6V sealed GEL batteries. This was USI's first collaboration with EcoEnergias, a Nicaraguan solar company.

4.1.5 San Jose

San Jose is a small rural town outside of San Ramon, where the people are heavily dependent on coffee farms for a source of income. After a day of work in the fields, many adults were eager to learn, but there was no access to electricity in the local school. USI partnered with Sister Communities of San Ramon to plan a 240W solar system to provide the school with LED lights and cell phone charging capabilities. The system was designed with 3 80W solar panels and one deep cycle 12V sealed battery, in collaboration with SuniSolar and completed in August of 2015.

4.1.6 Verapaz

Verapaz is a small village, located North of San Ramon, without access to electricity and with no connection to the grid in sight. A load assessment was conducted to determine the electricity needs for the school in Verapaz and a 200W system was designed to meet those needs. This system was installed August 11, 2015 in collaboration with SuniSolar, and was designed using 2 100W modules and one deep cycle 12V sealed battery.

4.2 USI Project Outcomes

We chose to analyze the assessments in order to look at whether or not the systems are reaching their planned objectives. Use of the system, including how many lights, outlets, phone chargers, etc., is compared to the purposed usage the system was designed to power. The load assessment includes plans for the space by Sister Communities of San Ramon. In the application process, information is provided regarding scheduling of night classes to be held in the school, community workshops, etc.

By delving into system designs we can see how large a system is, as well as how much energy it should be producing. We can see the battery bank size and what a healthy state of charge should be. Additionally, the amount of usage time that the system was designed to power without access to the sun can be determined as well.

Pictures of the location and of the completed system provide a better sense of the actual system. The relation of the systems to each other, and their proximity to the nearest developed region can be observed in the location snapshots.

USI's original process for monitoring the projects after the installation phase will be analyzed in depth. An analysis of the questions already asked, as well as things to look for that we have learned from the literature review, will be used to compile questions for a new survey. This survey will strengthen the quality of USI's monitoring process, while also providing data for analysis in this study.

4.3 Site Survey

The survey portion of this report was developed at Appalachian State, and administered using USI's partnership with Sister Communities of San Ramon (SCSR). Anjie Price from SCSR visited the project sites during school hours to conduct the surveys. She recorded system information and talked to community members, teachers, students, etc. in order to answer the remaining survey questions. Data was recorded electronically, using an iPad on location. The voltage of the batteries is measured using a Truper MUT-39 digital multi-meter tool.

The questions for the survey were developed using USI's original project evaluations as a guideline (figure 1). Using outcomes observed from the literature review of similar projects, significant changes were made in order to address the outcomes of the projects. For example, earlier we discussed that case studies have shown users tend to increase their electricity use in years after gaining access to it [13]. This led to development of the questions, "Who in the community is happy with the system? Is anyone unhappy?", as well as "If you could power additional items, what would they be?" These are crucial to learning whether or not people are happy with the system sizes, or if having access to electricity has made them realize that they want more. USI can use this information to better plan future projects, as well as potentially expand current ones.

Project Name ***Date***

Installation date:

1. How many people in the community have access to the school?
2. How many attend night classes?
3. What other community gatherings are utilizing the space at night?
4. How many hours a day is lighting used?
5. If you could power additional items, what would they be?
6. Have any requests been sent in to fix any equipment?
7. Are cell phone chargers working?
8. How long are the batteries lasting?
9. Are there any malfunctioning bulbs?
10. Is there any obstruction to solar panels? Do they need to be cleaned?
11. Is lighting working for length of night classes?

Additional comments:

Figure 1. Original USI evaluations

Research Survey: United Solar Initiative Project Outcomes

Battery:

Voltage (charging, no load)	
Weather Conditions	
Time of Day	

2. How many hours a day is lighting used? ____________
3. How long is the battery charge lasting? Do lights work for the length of night classes? How long?
4. How many light bulbs are currently working? Not working?
5. How many outlets are there? Are they being used? ____________
6. What is electricity being used for?
7. What are some suggestions you have for future projects? Additional items that could be powered?
8. How well are cell phone chargers working?
9. How many people in the community use the system daily? Weekend vs weekday?
10. Specifically, how many students or adults are enrolled in night classes? Year round or seasonal?
11. What community activities are utilizing the space at night?
12. Have the people or activities using the system changed since the system was first installed?
13. What requests, if any, have been sent in to fix any equipment?
14. Is there any obstruction to solar panels? Do they need to be cleaned?
15. Who is in charge of reporting repair needs?
16. Who in the community is happy with the system? Is anyone unhappy? Why?
17. Has there been any conflict with how/when the system is used?
18. Would you pay for a small fee for electricity use? How much?
19. Additional comments:

Figure 2. Survey conducted for the purpose of this study

The literature review showed us that a local and sustainable model is important for the long term success of a project, especially when the NGO has left the area [2,14]. This led to the development of questions like “Would you pay a small fee for electricity use? How much?” and “Who is in charge of reporting repair needs?” If the community members using the system would be willing to invest in it, even in just a small amount, USI could use this information to implement a more sustainable model. It is also important for sustainability purposes that everyone is aware of who the responsible party is for reporting repair needs.

In order for USI to ensure that the projects will remain operational for the longest possible time, it is necessary to check the status of the batteries in the systems. In order to do this, a simple chart was developed for the survey administrator to fill out, including the voltage of the battery with no load, the weather conditions, and the time of day. The battery voltage was measured with a simple multi-meter pictured in figure 3.

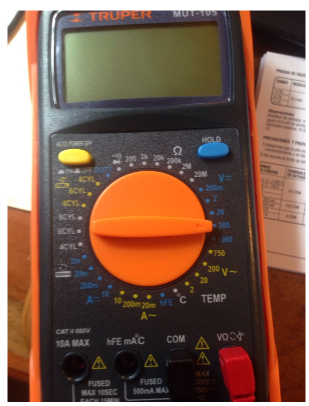

Figure 3. Truper MUT-39 digital multi-meter tool

In order to analyze the health of the batteries based on voltage, a test was conducted using 12volt AGM sealed batteries, the same ones used in the case study systems, in order to determine expected voltage at different battery levels in a healthy battery. The test was conducted in Appalachian State’s Sustainable Technology lab. The batteries were charged to full charge using a photovoltaic array, and the amp hours of the battery were recorded. The battery was connected to a load in order to draw out 25% of the charge, equivalent to ¼ of the amp hours. Then the PV system was turned back on and the voltage of the battery, while it was being charged, was measured. This provided an approximate voltage associated with various battery states of charge. The amp hours were measured using the meter attached to the DC junction box of the system. The voltage at 100%, 75%, 50%, 25%, and 0% charge were recorded. The information can be found in the table 1 below. This table is used to analyze the recorded voltage from the survey to determine the condition of the batteries.

Battery Voltage Test		
State of Charge	Amp Hours Used	Recorded Voltage
100%	0	14
75%	9.5	12.8
50%	19	12.4
25%	28.5	11.5
0%	38	10.6

Table 1. Relationship between amp hours used and recorded voltage

5.0 Results

5.1 Design Process and Rationale

The five systems installed by United Solar Initiative examined in this study have some overarching similarities, but are not exactly the same. Understanding the differences between them is crucial to properly analyze their success. Each system was designed separately, four of them designed by SuniSolar and only Santa Ana was designed by EcoEnergias. Each design was reviewed by USI; however, no changes were made. All of the projects used sealed batteries, a strategy by USI to simplify the maintenance of the systems, due to their rural locations and their use by community members that are not trained in PV technology. The four systems that have outlets (all but Arte Movimiento) are also equipped with inverters. This is crucial for converting the DC electricity to AC for use by devices such as cell phone chargers and stereos. The inverters were sourced by USI for the San Jose and Verapaz projects due to an in-kind donation. It is important to note that United Solar Initiative has hosted a training class following each installation with the principles, teachers, and some parents on the basics of PV to increase their understanding and address what to do/who to contact if something isn't working properly.

The design size was similar for four of the five systems, with Santa Ana being the exception. San Ramon, San Antonio de Upa, Verapaz, and San Jose are all roughly 200W systems. Santa Ana, however, is a larger 900W system. A minor difference in the San Ramon system was its potential access to electricity due to its location in a larger town. The other 4 systems are far from the grid, however the art school system is only a few blocks away from grid energy. Through discussions with USI, the reason to proceed with a solar system was made apparent. The local government has become incredibly unreliable, prioritizing baseball stadiums over electrifying schools. Without any promising news in the foreseeable future regarding the government acting to extend the grid to the school, USI decided to proceed with the installation.

5.2 Design vs. Use

Survey results for questions two through six, indicating current system use and information, gathered from the USI documentation on original system design are summarized in Table 2. This comparison shows the current system uses compared to their designs. The data for the intended lights and outlets was pulled from the load assessments and system designs found in the appendix. It can be observed that the systems are being used to their potential in most cases. San Jose was installed with 16 lights, however the data from this survey reveals that two of the outdoor lights have been stolen. San Antonio, San Jose, and

Verapaz all were designed with five outlets in mind, however it appears that only four are in operation. Further discussions with Sister Communities of San Ramon revealed that only four outlets were installed, calling into question SuniSolar's load assessment. This is something that USI should address before proceeding with SuniSolar on any further installations.

It is interesting to note the much larger system of Santa Ana having a similar load to the other systems. This prompted a discussion with USI as to the purpose of the larger system design, including four 235W panels and four 6V batteries. It was revealed that the school has the intention of holding larger events in the space monthly, that includes powering several high demand audio and visual systems that will draw a high load at one time. The community had also expressed interest in potentially expanding the system in the future to power housing for teachers who commute weekly to the school. In this case, proposed future use led USI to oversize the system. Looking at the data from question seven, community members expressed the desire for the ability to power more devices if they could.

Projects	**Lights Intended**	**Lights Used**	**Outlets Intended**	**Outlets Used**	**Other Uses**
Arte Movimiento	16	15	0	0	none
San Antonio	13	13	5	4	Charge cell phones
Santa Ana	10	10	1	1	Charge cell phones
San Jose	16	14	5	4	Charge cell phones
Verapaz	11	11	5	4	Charge cell phones

Table 2. System design versus current use

5.3 Current Status – Battery Health

Survey results for question one, in the form of a table, regarding the resting voltage of the system batteries can be found in Table 3. The measured voltage was compared to the table regarding the amp hours used and recorded voltage (Table 1), found in the methodologies, in order to determine the approximate battery charge. The battery charges for Arte Movimiento, San Antonio de Upa, Santa Ana, and Verapaz all reflect a healthy battery at first glance. Due to the systems being used daily, it is unreasonable to expect 100% charge, but a charge in the area of 75%-100% is a sign of a healthy battery. The results for San Jose are slightly concerning, with a resting voltage of 12.6 translating to a battery charge of approximately 50%-75%. This is something that USI should monitor with concern in the near future.

Projects	Nominal Voltage	Battery Voltage	Weather	Time of Day	Battery Charge
Arte Movimiento	12V	13.5	Overcast	11:19 AM	75-100%
San Antonio	12V	13.6	Overcast	10:31 AM	75-100%
Santa Ana	24V	26.6	Overcast	10:30 AM	75-100%
San Jose	12V	12.6	Unseasonably Sunny	11:15 AM	50-75%
Verapaz	12V	13.1	Unseasonably Sunny	11:50 AM	75-100%

Table 3. Battery measurements and associated battery health

5.4 User Experiences

Results from survey questions two, nine, ten, and eleven can be found in Table 4 showing the number of people that benefit from the systems and in what capacity. The data reveals that USI is benefiting 175 people directly through these five projects. One of the main purposes of these systems, as defined by USI, is to empower the local community through night classes as well. Unfortunately, we can see that night classes are only currently filled in Santa Ana and Verapaz. Thanks to the diligence of survey recorder Anjie Price administering questions three, ten, and sixteen, we can get a sense of why this is.

In Arte Movimiento in San Ramon the teachers and night guard have noticed that the battery has not been lasting as long as it used to. When the system was first installed, the batteries lasted the duration of the night classes, however they began going out by 9pm in June 2016, forcing the teachers to move the night classes to a different location. The report states that the night guard had been leaving outdoor lights on until the battery was empty as a means of security. This may be the cause to potential battery damage, or the reason that the battery may not be fully charging.

At the San Antonio de Upa school, the cause for no current night classes is very different. SCSR had arranged for night classes to be taught by a teacher who had been at the school for several years to begin after the installation in December 2014. Unfortunately, in the months following the installation, a tense situation developed. The neighboring hacienda owner started buying locals out to work for him, or threatening to take their land if they didn't have papers (a common tactic in communities where most adults are barely literate). This prevented many adults from being able to take the classes, forcing the teacher to transfer to a new location. In the time since, SCSR has been diligently working to replace the teacher, but it has taken time for her to get acclimated. USI and SCSR hope that night classes are a possibility in the upcoming future, but the challenges regarding San Antonio de Upa were difficult to predict, leading to the untapped potential of the system.

The system at the San Jose school has run into problems of their own that have prevented the hosting of night classes. SCSR has stated that the community is strongly divided by political beliefs, and that it is greatly affecting the ability to get adult literacy classes up and running. The fact that 2016 is an election year in Nicaragua has only increased the divide amongst community members. People are unwilling to work together, adults unwilling to teach those of other beliefs or even attend class with people of a different political party. Combine this with a recent changing of teachers at the school and night classes have yet to begin since the August 2015 installation. There is a strong hope that after the election, SCSR will have success with organizing night classes to begin. This is something that USI should monitor closely, and can learn from for future projects.

Projects	**Number of People With Access to System Daily**	**Number of People in Night Classes**	**Hours per day Lighting is Used**
Arte Movimiento	15	0	8
San Antonio	30	0	2
Santa Ana	50	13	6
San Jose	40	0	6
Verapaz	40	15	5
Sum	**175**	**28**	**27**
Average	**35**	**5.6**	**5.4**

Table 4. Number of people benefitting from system

6.0 Conclusion

The challenge of electrifying the billions of the world's population in the dark is a daunting one, one that is being taken on by a variety of organizations, from governments to non-profits. Photovoltaic solar installations are seen as the best solution by many due to its simplicity, site-flexible capabilities, and pairing well with low load applications. This has made it the priority of many NGOs, such as United Solar Initiative [3]. This study has allowed us to delve into five of USI's previous photovoltaic installations in Nicaragua. We have observed issues relating to system design compared to system use, procedures to ensure longevity, and reaching goals within community development. Analysis of the system components as well as the surveys administered by Sister Communities of San Ramon at each of the schools has provided us with significant areas of improvement for United Solar Initiative.

Looking at the design of the systems, we can note that USI has done well to insure that all of the installations use sealed batteries. This can add to the longevity of the systems by decreasing the risk of the batteries going bad due to poor maintenance. It is interesting to observe that USI has begun to take into account the fact that the communities have expressed an interest in adding future loads in the years following the installation. The literature reviewed in the study revealed that this is common among communities who gain access to electricity for the first time [13]. It is important for USI to design future systems with potential to support a greater load demand in the future. Specifically, designing 24V systems with 72 cell panels will provide enough electricity for communities to add stereos, computers, and more lights in the future.

In order to ensure a long and healthy system life for USI's projects, a battery health test was conducted with this survey. The results showed that four of the five systems appeared to have a healthy battery upon testing, with San Jose being the exception. The battery may have had a low charge due to high use the previous day, but if the system measures a low state of charge on the upcoming quarterly evaluations, it would be beneficial for USI to send a technician from SuniSolar or EcoEnergias to take a more detailed look. The battery may have been damaged during a period of unrecorded misuse and need replacement.

The qualitative analysis of the systems spotlighted a problem with the Arte Movimiento system in San Ramon. The community organizers and teachers have been forced to move the night classes previously held there to a new location because the batteries were depleted by 9pm every night. It was reported that the night guard has been leaving lights on every night as a form of security for the school, until the battery depletes around 3am. This constant use to a 0% charge may have harmed the battery, negatively affecting the amount of charge it can now hold. Another possible scenario is that the batteries may not be charging fully during the day because the daily load, meaning that they are only partially charged when the night classes begin. United Solar Initiative should recommend that the lights no longer be used for night security, and take this into account for future load assessments. The post-installation trainings that USI conducts with community members should be altered to include the hours a day that the lights/outlets should be used.

The lack of night classes being hosted at the San Antonio de Upa and San Jose schools is incredibly disconcerting. It is disheartening that the problems do not lie with the systems, a potentially simple fix, but with the organization of the community members through SCSR. USI should proceed with caution on future projects, ensuring night classes are a guarantee before installation begins. It is recommended that USI require a use proposal from Sister Communities for each individual project moving forward. This proposal should include a calendar of events for the school, a roster of adults signed up for literacy class, a signature of confirmation from the teacher responsible for the night class, and intended use of the system. This will not only add a level of accountability and due diligence for ensuring that night classes will take place, but it will also assist with the load assessments of the systems and facilitate a better understanding of exactly what the project will be used for.

The survey attempted to address the element of sustainability in United Solar Initiative's projects. Information from the surveys reveal that none of the school users are willing to pay a small fee for electricity, highlighting a challenging path to ensuring a stable source of funding for the project's longevity. USI is financially responsible for all maintenance within the first year, but they are working with SCSR to set up a sustainable solution for a long term fund. Community members pay a small fee for cell phone charging, and these funds are being set aside and monitored by SCRS. Arte Movimiento and Santa Ana have their space available for rent for community activities/events, charging a fee to be added to this fund as well. USI will continue to monitor battery health in order to assist with the maintenance, however financial independence is crucial for the longevity and success of the projects [2,14]. USI should continue to have SCSR pay 25% of the upfront system costs, creating a sense of ownership that adds to the sustainable design of their systems.

In order for USI to properly monitor their installed projects and continue to gather helpful data into the future, the survey used in this study can be altered to become their new quarterly evaluation form. An updated survey can be seen in the appendix as figure 28. This evaluation form includes an updated question number two in order to address what time of day the lighting is being used. This will allow USI to properly monitor whether or not the systems are being used for their intended design relating to night classes or day classes. Question number eight has been removed and replaced with a question relating to how many hours the outlets are being used to charge phones, as well as what time of day this is occurring, and weekday versus weekend parameters. This will give USI more concrete data as to exactly how the systems are being used. Question number 18 has been removed and it is recommended that USI perform a willingness to pay study separately. This can include in-depth conversations with system users and SCSR to find out the best strategies to strengthen the long term funding of these projects for maintenance. In order to strengthen USI's understanding of their projects moving forward, a data logging device should be installed on a current system or the next project in order to begin recording information on system use and battery status. This will allow USI to better understand exactly when and how the systems are operated.

United Solar Initiative has begun on a long and challenging mission to try to alleviate energy poverty in underprivileged communities in Nicaragua. They have seen some success, and have seen some failures. The goal of this report was to address ways in which USI can learn from their projects, and ways that they can implement change for future ones. With the lessons learned from this analysis and survey of the Arte Movimiento, San Antonio de Upa, San Jose, Verapaz, and Santa projects, along with the literature review and projects from other organizations, USI can continue to make a difference in the lives of families and children in Nicaragua.

7.0 Appendix

San Ramon - Arte Movimiento

Art School of San Ramon ***July 5th 2016***
Installation date: June 2014
NOTE: The art school system, like the one in the community center, are only for lighting – there are no outlets. Also, the art school is not due for a follow-up visit until September, but they called to report a problem with the batteries.

1. Battery:

   Voltage (charging, no load): 13.5
   Weather conditions: Overcast, sprinkling
   Time of day: 11:19am

2. How many hours a day is lighting used? Inside the building, usually 5 hours, but the outdoor bulbs are on all night for security reasons. However, since the batteries have not been lasting, they've moved night classes to a different location.

3. How long is the battery charge lasting? Do lights work for the length of night classes? The night guard says that if he leaves only one exterior light on, it goes out at about 2 or 3am (26uropea. 8-9 hours of light). If he leaves all three exterior lights on, they last till about 10pm (26uropea. 4 hours). When they were having music classes at night, the lights were going out by 9pm, so they moved the classes.

4. How many light bulbs are currently working? Not working? Of the 16 light bulbs, only one is not working.

5. How many outlets are there? Are they being used? There are no outlets in this system.

6. What is electricity being used for? N/A

7. If you could power additional items, what would they be? N/A

8. How well are cell phone chargers working? N/A

9. How many people in the community use the system daily? Weekend vs. weekday? If the music classes were still being held there, there would be 15 music students using the system every day. The space was also used for community meetings and public events, but now it's simply not being used at night.

10. Specifically, how many students or adults are enrolled in night classes? Right now there are 15 people enrolled in the music classes offered at night.

11. What other community gatherings are utilizing the space at night? Only music classes meet regularly, but the art school makes the space available for rent as a source of revenue for the school.

12. Have the people or activities using the system changed since the system was first installed? There is a new night guard, but he's been using a flashlight since the lights

don't last all night. Apart from him, the same people are using and maintaining the system.

13. Have any requests been sent in to fix any equipment? We received a call last week saying that the batteries are not charging like before. During our visit, they told us that a "fuse had burned," and that they replaced it. We took a photo of the part that had been replaced. It is attached to this document.

14. Is there any obstruction to solar panels? Do they need to be cleaned? The panels are being cleaned every month. There are no obstructions.

15. Who is in charge of reporting repair needs? The school director.

16. Who in the community is happy with the system? Is anyone unhappy? Why? The art school administration is unhappy with the fact that they can't use the system at night right now, which is the whole purpose of having the system.

17. Has there been any conflict with how/when the system is used? No.

18. Would you pay a small fee for electricity use? How much? I don't understand this question. Who is this question directed to?

19. Additional comments:

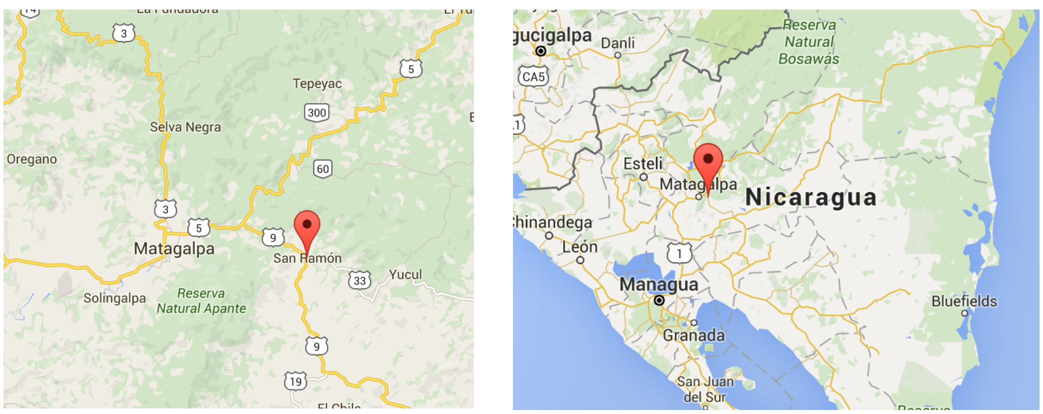

Figure 4. San Ramon location

Figure 5. Arte Movimiento system images

Area	Cantidad	Descripcion	Dias Uso	Tipo	Potencia Watts	Horas Uso		kWh/d	kW
	4	LED Lights	7	dc	5	13	100%	0.26	20
	12	LED Lights	7	dc	5	3	100%	0.18	60
							Total	**0.44**	**0.08**
							10%	**0.05**	**0.01**
							Total	**0.49**	**0.09**

Figure 6. Arte Movimiento load assessment

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ssinfo@sunisolar.com.
RUC J0310000147701

Día	Mes	Año

Oferta

Sres.	UNITED SOLAR INICIATIVE	**Teléfono**	
Atención		**email**	
Dirección			

ID	Unds	Descripción	Precio	Importe
	3	Solar Modules 80W	$120.00	$360.00
RA12150D	2	Deep Cycle Bateries Ritar sealed 150Ah 12VDC	$280.00	$280.00
	1	Charge Controller 20A 12V	$90.00	$90.00
	16	LED lightbulbs 5W 12VDC	$8.00	$128.00
	1	Materials Kit	$600.00	$600.00
	1	Labor and Training	$550.00	$550.00
	1	Transport	$100.00	$100.00
			Sub total	**$2,108.00**
			Impuesto	**$220.20**
			Total	**$2,328.20**

Validez de la oferta: 30 días

El equivalente de la oferta en córdobas se obtiene con la tasa de cambio oficial al día de la compra.
Ítems que no estén en stock tardan 15 días hábiles para estar disponibles.
De ser aceptada la oferta, favor firmarla y enviarla al fax (505) 22782630.

DOUGLAS GONZALEZ
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Figure 7. Arte Movimiento bill of materials

San Antonio de Upa

San Antonio de Upa ***July 13th 2016***
Installation date: December 2014

1. Battery:

    Voltage (charging, no load): 13.6
    Weather conditions: Overcast
    Time of day: 10:31am

2. How many hours a day is lighting used? Approximately 2 hours a day.
3. How long is the battery charge lasting? Do lights work for the length of night classes? Night classes never began, because after the large migration of last year, the only qualified teacher moved away.
4. How many light bulbs are currently working? Not working? All 14 bulbs are working. They usually use 10 of them.
5. How many outlets are there? Are they being used? There are four outlets, and all of them are being used.
6. What is electricity being used for? To charge cell phones for about three hours a day.
7. If you could power additional items, what would they be? Perhaps a radio with a cd player.
8. How well are cell phone chargers working? Good.
9. How many people in the community use the system daily? Weekend vs. weekday? Approximately 30 people used the system during weekdays, including children and adults who charge their cell phones. The system is not used on the weekend.
10. Specifically, how many students or adults are enrolled in night classes? None.
11. What other community gatherings are utilizing the space at night? Meetings of community leaders.
12. Have the people or activities using the system changed since the system was first installed? No.
13. Have any requests been sent in to fix any equipment? No, using the funds from cell phone charging, they pay someone to handle repairs.
14. Is there any obstruction to solar panels? Do they need to be cleaned? The panels are being cleaned every month. There are no obstructions.
15. Who is in charge of reporting repair needs? The president of the Parents' Association..
16. Who in the community is happy with the system? Is anyone unhappy? Why? No.
17. Has there been any conflict with how/when the system is used? No.

18. Would you pay a small fee for electricity use? How much? No.

19. Additional comments: The problem in San Antonio de Upa continues to be the fact that almost half the community moved away when the neighboring hacienda changed owners, and the new owner started buying people out (or threatening to take their land because they didn't have papers – a common tactic in communities where most adults are barely literate). Also, the excellent teacher who was here before was transferred, and the new one is taking a while to get acclimated.

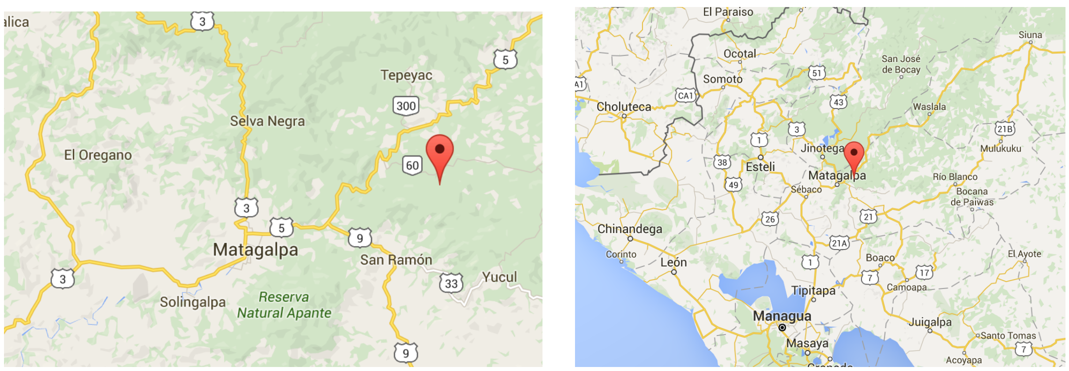

Figure 8. San Antonio de Upa location

Figure 9. San Antonio de Upa images (Charlie Egan and Steven Thomsen from USI pictured on right)

Area	Cantidad	Descripción	Días Uso	Tipo	Potencia Watts	Horas Uso		kWh/d	kW
	8	CFL Lights	7	ac	11	3	100%	0.264	88
	5	CFL Lights	7	ac	11	3	100%	0.165	55
	5	Cell phone	7	ac	7	5	100%	0.175	35
							Total	**0.60**	**0.18**
							10%	**0.06**	**0.02**
							Total	**0.66**	**0.20**

Figure 10. San Antonio de Upa load assessment

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ssinfo@sunisolar.com.
RUC J0310000147701

Día	Mes	Año
11	4	2014

Oferta

Sres.	Steven Thompsen	**Teléfono**	
Atención		**email**	sthomsen@stratasolar.com
Dirección			

ID	Unds	Descripción	Precio	Importe
	2	Solar Modules 100W	$150.00	$300.00
	2	Ritar Deep cycle batteries AGM 150Ah 12VDC	$252.00	$504.00
	1	Charge Controller 20A 12V	$90.00	$90.00
	1	Modified Sine Wave Inverter 800W	$100.00	$100.00
	2	30A Switch blade	$5.00	$10.00
	1	Delta Surge Arrestor	$50.00	$50.00
	2	Jumper AWG 8 battery parallel	$3.00	$6.00
	2	Jumper AWG 8 for inverter	$8.00	$16.00
	1	Battery cage	$40.00	$40.00
	1	Materials Kit	$461.00	$461.00
	1	Labor and Training	$500.00	$500.00
	1	Transport	$100.00	$100.00
			Sub total	**$2,177.00**
			Impuesto	**$205.95**
			Total	**$2,382.95**

Validez de la oferta: 30 días

El equivalente de la oferta en córdobas se obtiene con la tasa de cambio oficial al día de la compra.
Ítems que no estén en stock tardan 15 días hábiles para estar disponibles.
De ser aceptada la oferta, favor firmarla y enviarla al fax (505) 22782630.

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Figure 11. San Antonio de Upa bill of materials

Santa Ana

Santa Ana ***July 14th 2016***
Installation date: June 2016

1. Battery:

   Voltage (charging, no load): 26.6
   Weather conditions: Overcast
   Time of day: 10:30am
2. How many hours a day is lighting used? Lighting is used for six hours.
3. How long is the battery charge lasting? Do lights work for the length of night classes? Before the installation of the system, classes were being held in a church. They were on vacation for the mid-year break, but they will commence soon in the school.
4. How many light bulbs are currently working? Not working? All 11 bulbs are working.
5. How many outlets are there? Are they being used? There is one, and it's working.
6. What is electricity being used for? Currently it is only being used to charge cell phones.
7. If you could power additional items, what would they be? Perhaps an electric stove to prepare food, or when teacher housing is built, some more lighting.
8. How well are cell phone chargers working? Good.
9. How many people in the community use the system daily? Weekend vs. weekday? There are approximately 50 children enrolled in the school, but not many people are charging cell phones because lots of houses in this community already have solar panels and offer this service.
10. Specifically, how many students or adults are enrolled in night classes? There are 13 adults enrolled in night classes.
11. What other community gatherings are utilizing the space at night? Parents' Association meetings.
12. Have the people or activities using the system changed since the system was first installed? No.
13. Have any requests been sent in to fix any equipment? No.
14. Is there any obstruction to solar panels? Do they need to be cleaned? No. The panels will be cleaned once a month.
15. Who is in charge of reporting repair needs? The president of the Parents' Association..
16. Who in the community is happy with the system? Is anyone unhappy? Why? No.

17. Has there been any conflict with how/when the system is used? No.

18. Would you pay a small fee for electricity use? How much? The Parents' Association is considering holding activities in the evening, or offering the space for rent. They would charge 30 cordobas for the use of the space.

19. Additional comments: One member of the Parents' Association mentioned that they have a small solar panel that was donated by another organization and wanted to know if we could provide a small battery for that panel. I told him that it was doubtful, but we would consider it. He also mentioned that they want to eventually build housing for the teachers (they travel weekly to the community), and if possible, they'd like to install an extension so that the teachers could have lighting.

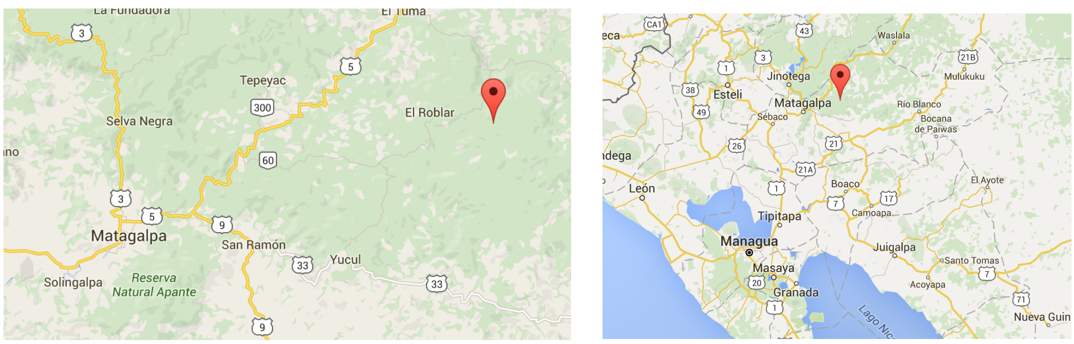

Figure 12. Santa Ana location

Figure 13. Santa Ana images

Use	Watts	Hours	Days/week	Wh/wk
Cell Phone Charging	5	2	7	70
LED TV	80	2	5	800
DVD Player	15	2	5	150
10 LED Lights	7	12	7	588
Sound System	400	1	1	400
Total				**2008**

Figure 14. Santa Ana load assessment

	ESCUELA SANTA ANA			
	con baterias de GEL alemanas			
	DESCRIPCION	Cantidad	Unitario	Total US $
1	PANELES 235 W y estructura de techo	4	376	1504
2	Controlador Steca 3030	1	165	165
3	Inversor Phocos 24 VDC/120 VAC/60 Hz 700 W Pure Sinewave	1	350	350
4	Baterias Hoppecke GEL 6V/250 AH con su caja metal	4	370	1480
6	Materiales instalacion electrica y arrestores	1	650	650
7	Mano de Obra y transporte	1	450	450
	SUB-TOTAL US $			4599
	Impuesto 15%			689.85
	TOTAL US $			5288.85
	10 lamparas LED 12 VDC/7W			
	Aterrizaje de equipos y estructura			
	Caja metalica de proteccion de baterias y candado			
	Instalacion electrica para 10 lamparas y dos enchufes con caja de breakers			
	Solar modules are 34uropean quality			

Figure 15. Santa Ana bill of materials

San Jose

San Jose ***July 15th 2016***
Installation date: August 2015

1. Battery:

   Voltage (charging, no load): 12.6 and 12.6
   Weather conditions: Unseasonably sunny
   Time of day: 11:15am

2. How many hours a day is lighting used? On overcast mornings or during evening events, lighting is used for six hours.

3. How long is the battery charge lasting? Do lights work for the length of night classes? During the times that the lights have been used, they have never gone out. Adult education classes still have not begun in this community.

4. How many light bulbs are currently working? Not working? There are only 14 bulbs, because two outdoor bulbs were stolen. All of the bulbs are working.

5. How many outlets are there? Are they being used? There are four outlets, and all of them are being used.

6. What is electricity being used for? Currently it is only being used to charge cell phones.

7. If you could power additional items, what would they be? Perhaps a radio with a cd player.

8. How well are cell phone chargers working? Good.

9. How many people in the community use the system daily? Weekend vs. weekday? Approximately 40 people used the system during weekdays. The system is not used on the weekend.

10. Specifically, how many students or adults are enrolled in night classes? Right now no one is enrolled in night classes.

11. What other community gatherings are utilizing the space at night? The most recent meeting held at the school was a meeting with representatives from the Ministry of Education.

12. Have the people or activities using the system changed since the system was first installed? Yes. Both of the teachers were transferred to different schools. (This is common right before an election- teachers get placed strategically according to their politics.) The two new teachers learned about the system and its functioning during our visit.

13. Have any requests been sent in to fix any equipment? No.

14. Is there any obstruction to solar panels? Do they need to be cleaned? The panels are being cleaned every month. There are no obstructions.

15. Who is in charge of reporting repair needs? The president of the Parents' Association..

16. Who in the community is happy with the system? Is anyone unhappy? Why? The teacher and community leader present said no. They said they are very thankful.

17. Has there been any conflict with how/when the system is used? The teacher and community leader present said no.

18. Would you pay a small fee for electricity use? How much? No.

19. Additional comments: Though the teacher and community leader said there have been no conflicts, our impression was that there is not much community unity in San Jose because the community seems to be pretty clearly divided along political lines. This being an election year, these divisions are stronger. We also noticed a lack of initiative on the part of the new teachers- we had to return twice to this school because the teacher forgot to notify the community leader that we would be arriving to inspect the system.

    There was really no way to anticipate this lack of leadership before installation – all we can hope is that after the election is over, things we calm down and people will go back to working together again.

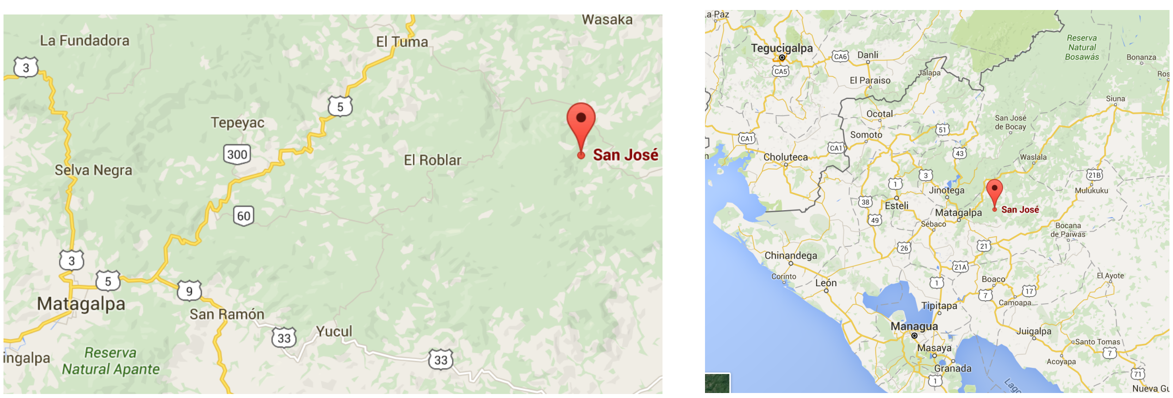

Figure 16. San Jose location

Figure 17. San Jose images

Area	Cantidad	Descripción	Días Uso	Tipo	Potencia Watts	Horas Uso		kWh/d	kW
	4	LED Lights	7	dc	5	13	100%	0.26	20
	12	LED Lights	7	dc	5	3	100%	0.18	60
	5	Cell phone	7	dc	7	5	100%	0.175	35
							Total	**0.62**	**0.12**
							10%	**0.06**	**0.01**
							Total	**0.68**	**0.13**

Figure 18. San Jose load assessment

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RUC J0310000147701

Día	Mes	Año
31	7	2015

Oferta

Sres.	UNITED SOLAR INICIATIVE	**Teléfono**	
Atención	TY FENTON	**email**	tfenton@unitedsolarinitiative.org
Dirección	SAN JOSE SCHOOL		

ID	Unds	Descripción	Precio	Importe
	3	Solar Modules 80W	$120.00	$360.00
RA12150D	1	Deep Cycle Bateries Ritar sealed 150Ah 12VDC	$280.00	$280.00
	1	Charge Controller 20A 12V	$90.00	$90.00
	16	LED lightbulbs 5W 12VDC	$8.00	$128.00
	1	Materials Kit	$600.00	$600.00
	1	Labor and Training	$550.00	$550.00
	1	Transport	$100.00	$100.00
			Sub total	**$2,108.00**
			Impuesto	**$220.20**
			Total	**$2,328.20**

Validez de la oferta: 30 días

El equivalente de la oferta en córdobas se obtiene con la tasa de cambio oficial al día de la compra.
Ítems que no estén en stock tardan 15 días hábiles para estar disponibles.
De ser aceptada la oferta, favor firmarla y enviarla al fax (505) 22782630.

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Figure 19. San Jose bill of materials

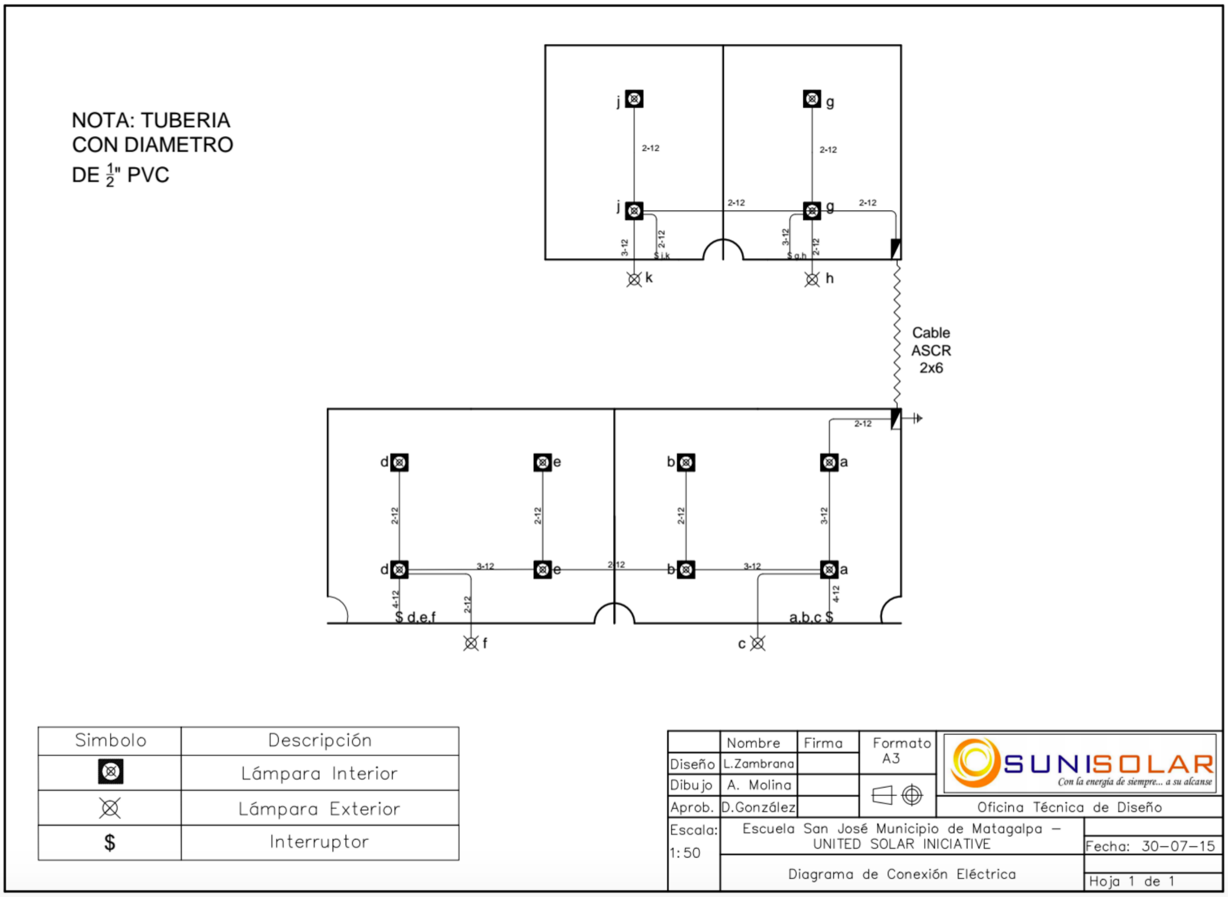

Figure 20. San Jose system layout

Verapaz

Verapaz ***July 15th***
2016
Installation date: August 2015

1. Battery:

   Voltage (charging, no load): 13.1
   Weather conditions: Unseasonably sunny
   Time of day: 11:50am

2. How many hours a day is lighting used? Approximately 5 hours.

3. How long is the battery charge lasting? Do lights work for the length of night classes? When classes were being held, they lasted the length of the classes. Because the Ministry of Education was so slow to assign a teacher for night classes, a religious non-profit from the community was paying a teacher to give classes for a few months. It was going well, but the non-profit discontinued payments, so the teacher quit.

4. How many light bulbs are currently working? Not working? All 11 bulbs are working.
5. How many outlets are there? Are they being used? There are four outlets, and all of them are being used.
6. What is electricity being used for? Currently it is only being used to charge cell phones for about 7 hours a day.
7. If you could power additional items, what would they be? Perhaps a radio with a cd player.
8. How well are cell phone chargers working? Good.
9. How many people in the community use the system daily? Weekend vs. weekday? Approximately 40 people used the system during weekdays. The system is not used on the weekend.
10. Specifically, how many students or adults are enrolled in night classes? There were approximately 15 adults in class when they were still being held.
11. What other community gatherings are utilizing the space at night? Meetings of community leaders and of the Parents' Association.
12. Have the people or activities using the system changed since the system was first installed? No.
13. Have any requests been sent in to fix any equipment? No. (Money from the cell phone charging is being set aside to cover the cost of new bulbs.)
14. Is there any obstruction to solar panels? Do they need to be cleaned? The panels are being cleaned every month. There are no obstructions.
15. Who is in charge of reporting repair needs? The president of the Parents' Association..
16. Who in the community is happy with the system? Is anyone unhappy? Why? No.
17. Has there been any conflict with how/when the system is used? No.
18. Would you pay a small fee for electricity use? How much? No.
19. Additional comments: The difference between this school and San Jose was striking. A large group of mothers came out to receive us at the school, and since the pre-school teacher is from the community, she was informed about its use and maintenance. They told us that they have used the money from charging cell phones to host community celebrations at the school, such as the Mother's Day, Children's Day, and New Year's. They were very proud to tell us about this.

Figure 21. Verapaz location

Figure 22. Verapaz images

Area	Cantidad	Descripción	Días Uso	Tipo	Potencia Watts	Horas Uso		kWh/d	kW
	3	LED Lights	7	dc	5	13	100%	0.195	15
	8	LED Lights	7	dc	5	3	100%	0.12	40
	5	Cell phone	7	dc	7	5	100%	0.175	35
							Total	**0.49**	**0.09**
							10%	**0.05**	**0.01**
							Total	**0.54**	**0.10**

Figure 23. Verapaz load assessment

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Barrio Edgar Munguía. Semáforos de ENEL Central 50 metros al sur. Pista hacia UNAN.
✆: 2278-2630/6644
✉: ssinfo@sunisolar.com.
RUC J0310000147701

Día	Mes	Año
31	7	2015

Oferta

Sres.	UNITED SOLAR INICIATIVE	**Teléfono**	
Atención	TY FENTON	**email**	tfenton@unitedsolarinitiative.org
Dirección	VERAPAZ SCHOOL		

ID	Unds	Descripción	Precio	Importe
	2	Solar Modules 100W	$150.00	$300.00
RA12150D	1	Deep Cycle Bateries Ritar sealed 150Ah 12VDC	$280.00	$280.00
	1	Charge Controller 20A 12V	$90.00	$90.00
	11	LED lightbulbs 5W 12VDC	$8.00	$88.00
	1	Materials Kit	$400.00	$400.00
	1	Labor and Training	$500.00	$500.00
	1	Transport	$100.00	$100.00
			Sub total	**$1,758.00**
			Impuesto	**$176.70**
			Total	**$1,934.70**

Validez de la oferta: 30 días

El equivalente de la oferta en córdobas se obtiene con la tasa de cambio oficial al día de la compra.
Ítems que no estén en stock tardan 15 días hábiles para estar disponibles.
De ser aceptada la oferta, favor firmarla y enviarla al fax (505) 22782630.

DOUGLAS GONZALEZ
Entregué Conforme

Recibí Conforme

Figure 24. Verapaz bill of materials

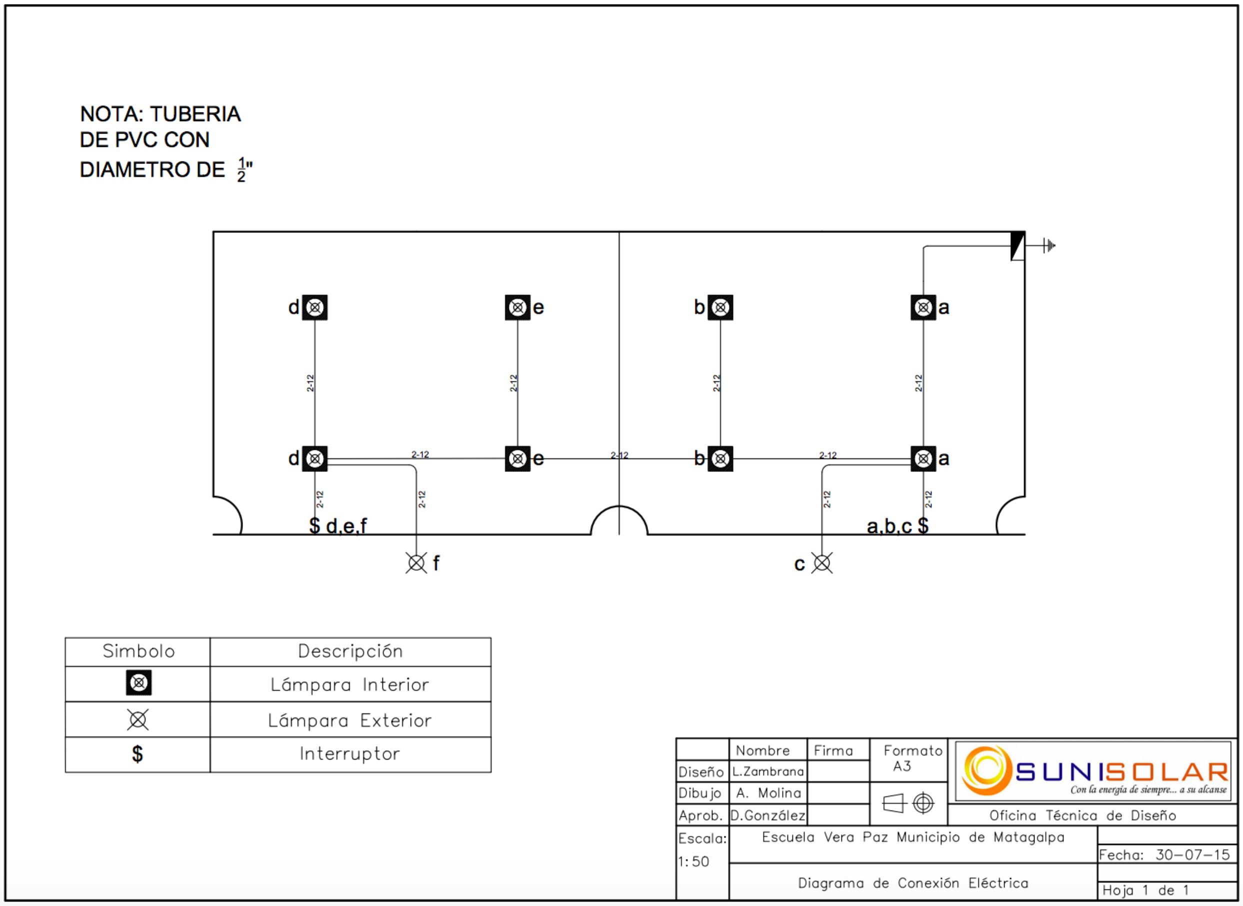

Figure 25. Verapaz system layout

Millennium Development Goals (MDGs)

Goals and Targets (from the Millennium Declaration)	Indicators for monitoring progress
Goal 1: Eradicate extreme poverty and hunger	
Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	**1.** Proportion of population below $1 (PPP) per day[a] **2.** Poverty gap ratio [incidence x depth of poverty] **3.** Share of poorest quintile in national consumption
Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	**4.** Prevalence of underweight children under-five years of age **5.** Proportion of population below minimum level of dietary energy consumption
Goal 2: Achieve universal primary education	
Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	**6.** Net enrolment ratio in primary education **7.** Proportion of pupils starting grade 1 who reach grade 5 **8.** Literacy rate of 15-24 year-olds
Goal 3: Promote gender equality and empower women	
Target 4: Eliminate gender disparity in primary and secondary education preferably by 2005 and to all levels of education no later than 2015	**9.** Ratios of girls to boys in primary, secondary and tertiary education **10.** Ratio of literate females to males of 15-24 year-olds **11.** Share of women in wage employment in the non-agricultural sector **12.** Proportion of seats held by women in national parliament
Goal 4: Reduce child mortality	
Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	**13.** Under-five mortality rate **14.** Infant mortality rate **15.** Proportion of 1 year-old children immunised against measles
Goal 5: Improve maternal health	
Target 6: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio	**16.** Maternal mortality ratio **17.** Proportion of births attended by skilled health personnel
Goal 6: Combat HIV/AIDS, malaria and other diseases	
Target 7: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	**18.** HIV prevalence among 15-24 year old pregnant women **19.** Condom use rate of the contraceptive prevalence rate[b] **20.** Number of children orphaned by HIV/AIDS[c]
Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	**21.** Prevalence and death rates associated with malaria **22.** Proportion of population in malaria risk areas using effective malaria prevention and treatment measures[d] **23.** Prevalence and death rates associated with tuberculosis **24.** Proportion of tuberculosis cases detected and cured under directly observed treatment short course (DOTS)
Goal 7: Ensure environmental sustainability	
Target 9: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	**25.** Proportion of land area covered by forest **26.** Ratio of area protected to maintain biological diversity to surface area **27.** Energy use (kg oil equivalent) per $1 GDP (PPP) **28.** Carbon dioxide emissions (per capita) and consumption of ozone-depleting CFCs (ODP tons) **29.** Proportion of population using solid fuels
Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water	**30.** Proportion of population with sustainable access to an improved water source, urban and rural
Target 11 By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	**31.** Proportion of urban population with access to improved sanitation **32.** Proportion of households with access to secure tenure (owned or rented)

Goal 8: Develop a global partnership for development	
Target 12: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system Includes a commitment to good governance, development, and poverty reduction – both nationally and internationally **Target 13**: Address the special needs of the least developed countries Includes: tariff and quota free access for least developed countries' exports; enhanced programme of debt relief for HIPC and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction **Target 14**: Address the special needs of landlocked countries and small island developing States (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly) **Target 15**: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term	*Some of the indicators listed below are monitored separately for the least developed countries (LDCs), Africa, landlocked countries and small island developing States.* *Official development assistance* **33.** Net ODA, total and to LDCs, as percentage of OECD/DAC donors' gross national income **34.** Proportion of total bilateral, sector-allocable ODA of OECD/DAC donors to basic social services (basic education, primary health care, nutrition, safe water and sanitation) **35.** Proportion of bilateral ODA of OECD/DAC donors that is untied **36.** ODA received in landlocked countries as proportion of their GNIs **37.** ODA received in small island developing States as proportion of their GNIs *Market access* **38.** Proportion of total developed country imports (by value and excluding arms) from developing countries and LDCs, admitted free of duties **39.** Average tariffs imposed by developed countries on agricultural products and textiles and clothing from developing countries **40.** Agricultural support estimate for OECD countries as percentage of their GDP **41.** Proportion of ODA provided to help build trade capacity[e] *Debt sustainability* **42.** Total number of countries that have reached their HIPC decision points and number that have reached their HIPC completion points (cumulative) **43.** Debt relief committed under HIPC initiative, US$ **44.** Debt service as a percentage of exports of goods and services
Target 16: In co-operation with developing countries, develop and implement strategies for decent and productive work for youth	**45.** Unemployment rate of 15-24 year-olds, each sex and total[f]
Target 17: In co-operation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries	**46.** Proportion of population with access to affordable essential drugs on a sustainable basis
Target 18: In co-operation with the private sector, make available the benefits of new technologies, especially information and communications	**47.** Telephone lines and cellular subscribers per 100 population **48.** Personal computers in use per 100 population and Internet users per 100 population

The Millennium Development Goals and targets come from the Millennium Declaration signed by 189 countries, including 147 Heads of State, in September 2000 (www.un.org/documents/ga/res/55/a55r002.pdf - A/RES/55/2). The goals and targets are inter-related and should be seen as a whole. They represent a partnership between the developed countries and the developing countries determined, as the Declaration states, "to create an environment – at the national and global levels alike – which is conducive to development and the elimination of poverty."

[a] For monitoring country poverty trends, indicators based on national poverty lines should be used, where available.

[b] Amongst contraceptive methods, only condoms are effective in preventing HIV transmission. The contraceptive prevalence rate is also useful in tracking progress in other health, gender and poverty goals. Because the condom use rate is only measured amongst women in union, it will be supplemented by an indicator on condom use in high risk situations. These indicators will be augmented with an indicator of knowledge and misconceptions regarding HIV/AIDS by 15-24 year-olds (UNICEF – WHO).

[c] To be measured by the ratio of proportion of orphans to non-orphans aged 10-14 who are attending school.

[d] Prevention to be measured by the % of under 5s sleeping under insecticide treated bednets; treatment to be measured by % of under 5s who are appropriately treated.

[e] OECD and WTO are collecting data that will be available for 2001 onwards.

[f] An improved measure of the target is under development by ILO for future years.

Figure 26. Eight Millennium Development Goals

Average Temperature (° C)													
Lat 11.3 Lon 85.8	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max Value
10-year Average	29.3	30	31	31	29	28	28.6	29	28	28	29	29	30.7

Average Daily Radiation on Horizontal Surface ($kWh/m^2/day$)													
Lat 11.3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av Value
10-year Average	6.89	7.26	7.5	7	6.3	6	6.25	6.2	5.7	5.9	6.2	6.5	6.47833

Figure 27. Nicaraguan irradiance and temperature statistics

United Solar Initiative Quarterly Evaluation Form

Battery:

Voltage (charging, no load)	
Weather Conditions	
Time of Day	

2. How many hours is lighting used during the day? At night? ____________
3. How long is the battery charge lasting? Do lights work for the length of night classes? How long?
4. How many light bulbs are currently working? Not working?
5. How many outlets are being used? ____________
6. What is electricity being used for?
7. What are some suggestions you have for future projects? Additional items that could be powered?
8. How many hours are phones being charged daily? What time of day? Weekend vs weekday?
9. How many people in the community use the system daily? Weekend vs weekday?
10. Specifically, how many students or adults are currently enrolled in night classes?
11. What community activities are utilizing the space at night?
12. Have the people or activities using the system changed since the system was first installed?
13. What requests, if any, have been sent in to fix any equipment?
14. Is there any obstruction to solar panels? Do they need to be cleaned?
15. Who is in charge of reporting repair needs?
16. Who in the community is happy with the system? Is anyone unhappy? Why?
17. Has there been any conflict with how/when the system is used?
18. Additional comments:

Figure 28. New USI quarterly evaluation form

8.0 Sources

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