

# NuSol

## Capacity Fund

Bringing **light** and **power** to the remote corners of our world



**REPORT** | Rural Electrification Program Evaluation  
**SITE** | Nueva Unión, Peru  
**PUBLICATION DATE** | Fall 2011



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- *The Community of Nueva Unión.* Their hard work, creative spirit, and daily dedication led to the success of this project. Pictured below are community members. Left: children outside the community school. Right: residents assisting with the unloading of project equipment.



- *In-Country Evaluation Staff* – Januer Campos’ and Milker Vega’s fluency in Quechua was a tremendous asset in a community where this is the primary language for more than half the residents.
- *Community Organizers* – Olinda Quispe and Arepina Aranda’s excellent cooking during the community survey session exceeded expectations. The community turnout helped in streamlining the surveying process.
- *Corporate, Nonprofit, and Individual Contributors* – Dedicated supporters who share in NuSol’s mission make this work possible.



Januer Campos and Milker Vega conducting an interview



Puerto Rican Cuisine



Olinda Quispe and Arepina Aranda preparing a community meal

## INTRODUCTION

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This report provides an in-depth look at the findings from the evaluation of NuSol Capacity Fund's first rural electrification project in Nueva Unión, Peru. The evaluation was conducted on-site in Nueva Unión by NuSol staff in July 2011, six months after project completion.

Initiated in late 2010, NuSol's pilot project now serves as a clean, renewable energy source for the more than 350 residents of Nueva Unión. This project consists of the installation of a 2.6 kW solar array that provides power and light to the community's primary school, medical post, communal house and charging station. The charging station allows residents within the community to recharge their LED lanterns, issued as part of the project, for nightly use to aid in a variety of household tasks and make nighttime reading/studying possible. The lanterns also serve as an inexpensive alternative to traditional lighting sources that tend to be more costly and polluting.

In planning the organization's evaluation strategy, NuSol applied best practices from the field of program evaluation pertaining specifically to rural electrification and sustainable development. A report that establishes this methodology can be found online in the University of Washington's Daniel J. Evans School of Public Affairs Degree Project Archive<sup>1</sup>.

The information collected during the evaluative site visit assesses how NuSol's work is contributing to sustainable development, and examines the unique project outcomes within the beneficiary community.

NuSol places great value in program evaluation as it provides data from which evidence-based decisions can be made to improve the outcomes of future projects. We view evaluation as an opportunity to assess our rural electrification efforts in terms of strengths and weaknesses, thereby learning and continuously improving our program offerings for future un-electrified communities with whom we will collaborate and serve.

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<sup>1</sup> <http://evans.washington.edu/students/forms-advising/degree-projects/archive/grid-rural-electrification-projects-practical-approach-evaluating-sustainabili-0>

### A Theme/Sub-Theme Framework

NuSol’s program evaluation strategy applies a theme/sub-theme framework to outline its program outcomes. A theme-sub theme framework is an organizational structure of characterizing program outcomes. The structure begins in the most general of terms, called the outcome category. Descriptions then become increasingly more detailed through the use of themes, sub-themes, and individually measurable indicators. This level of specificity increases the practicality during the actual evaluation/surveying process, and improves the understandability of information and how it relates to overarching themes. This framework is visually depicted here in Table 1:

Outcome Category	Theme	Sub-Theme	Indicator
			Indicator
		Sub-Theme	Indicator
			Indicator
	Theme	Sub-Theme	Indicator
			Indicator
		Sub-Theme	Indicator
			Indicator

NuSol has identified 2 main outcome categories, Sustainability and Project Specific, 7 outcome themes, 19 outcome sub-themes, and 37 measureable indicators pertaining to its work. Figure 2 on the following page depicts NuSol’s use of the theme/sub-theme structure as it pertains to actual outcomes/indicators on which this evaluation was based.

Within the outcome category Sustainability, the four outcome themes are defined as follows:

1. **Technical Sustainability:** Relating to the performance, reliability and long-term feasibility of the energy system from a mechanical and community capacity perspective.
2. **Economic Sustainability:** This theme relates to the financial sustainability of the project, including equipment, installation and maintenance costs. Economic sustainability should also encourage economic development within the target population as a result of the intervention.
3. **Social/Ethical Sustainability:** This theme includes issues regarding the equitable distribution of electrification services, both for private and public use, and the availability of credit options.
4. **Environmental Sustainability:** This theme can be interpreted from the local to global level. For example, improved air quality, improved cooking options, resource preservation, etc. within the target community and also the impact on a global scale, if applicable.

Within the outcome category Project Specific, the three outcome themes are defined as follows:

5. **Domestic:** Relating to impacts within the household as a result of the intervention. Indicators include, but are not limited to, improved lighting, air quality, safety, and efficiency.
6. **Productive:** Relating to the household financial impacts of the intervention, including decreased spending on traditional energy related resources and increased monthly household income.
7. **Public:** Relating to impacts on community education, health, and development. Indicators include, but are not limited to changes in reading habits and improved infrastructure.

An explanation of each of the measurable indicators is included in the Analysis portion of this report.

**Table 2: NuSol Capacity Fund - Outcomes / Indicators**

Outcome Category	Theme	Sub-Theme	Indicators	
Sustainability	1. Technical	Operational Feasibility	1	System functionality
			2	System depreciation
			3	Stable electricity usage
			4	Compatibility with future grid services or expansion
			5	Conformance with national/regional/industry standards
		Community Capacity	6	Availability of support infrastructure
			7	Readily available services
	2. Economic	Financial	8	Capital and installation cost
			9	Operation and maintenance costs ( <i>linked with indicator 1 &amp; 2</i> )
			10	Share of profit set aside for re-investment (batteries, system repairs)
		Productive Uses	11	Percent of electricity consumed by businesses
			12	Percent of electrified households using electricity for income generating activity
		Employment Generation	13	Businesses developed
	3. Social/Ethical	Equitable Distribution	14	Percent of community with access to light
			15	Percent of community with access to electricity
		Availability in Public Spaces	16	Health centers with electricity and light
			17	Schools with electricity and light
			18	Public gathering areas with light and electricity
		Credit	19	Micro-credit options available for renewable energy expansion
4. Environmental	Community	20	Percent of electrified households where renewable electricity has replaced other energy sources for lighting	
		21	Percent of electrified households where renewable electricity has replaced other energy sources for cooking	
		22	A unique environmental impact identified	
	Global	23	Quantity of renewable energy consumed	
		24	Improved brightness of light	
Project Specific	5. Domestic	Household Lighting	25	Improved reliability from renewable light source ( <i>linked with indicator 7</i> )
			26	Improved duration of light from renewable light source
			27	Improved air quality within households ( <i>linked with indicators 21-24</i> )
		Household safety	28	Improved safety within households
		Efficiency	29	Increased availability of time for other household tasks ( <i>linked with 7 &amp; 26</i> )
		Information dissemination and communication	30	Increased use of periphery devices within households
	6. Productive	Household Financial	31	Decrease in monthly household expenditures on energy-related resources
			32	Increase in monthly household revenues ( <i>linked with indicators 12-14</i> )
	7. Public	Education	33	Increased time spent reading (change in reading habits) among youth ( <i>linked with indicator 7 &amp; 26</i> )
			34	Infrastructure capable of accommodating electronic teaching resources ( <i>linked with indicator 18</i> )
		Health	35	Infrastructure capable of accommodating more advanced medical resources ( <i>linked with indicator 17</i> )
			36	Improved public lighting ( <i>linked with indicator 19</i> )
		Community Development	37	Improved / development of community security ( <i>linked with indicator 19 &amp; 37</i> )

## EVALUATION METHODOLOGY CONTINUED

The evaluation was structured into two distinct components:

1. **Household Survey** – This survey was administered to households receiving solar energy services (one survey per household). It is intended to assess the impact of these services on the lives of individuals and their families. The survey examines a number of indicators pertaining to unique project specific outcomes and system sustainability. The survey also examines client satisfaction with the solar energy services. The survey was administered in paper format for those able to read Spanish and also conveyed orally in Spanish and Quechua for those preferring a spoken interview.
2. **Technical Inspection** – To ensure the technical sustainability and proper use of the solar energy system, NuSol staff independently examined system components to assure they were functioning and being maintained appropriately.



Community members attending the gathering

The household survey was conducted in two stages:

1. **Group Format** – To efficiently administer surveys to households, the NuSol team hosted a community gathering where several residents cooked food for those that attended. As the community values the sharing of meals with one another, this event created both an incentive to attend and a casual environment where NuSol staff could talk with residents about the project.
2. **Individual Format** – In an effort to reach out to residents that live further from the town center and were therefore unable to attend the community gathering, NuSol staff made individual visits to residents' homes to conduct the household survey.



Interviews with more rural community members

### ABOUT THE COMMUNITY SURVEYED - NUEVA UNIÓN

- Households Served: 70
- Individuals Served: 350
- Households Surveyed: 40 (57%)
- Female Head of Households Surveyed: 15 (37.5% of households surveyed)

### UNIQUE FACTORS INFLUENCING THE EVALUATION PROCESS

The residents of Nueva Unión are primarily supported by subsistence agriculture and raising livestock. The NuSol evaluation site visit occurred during the harvest season, and unfortunately a number of residents had left the community to find wage labor in neighboring towns, to assist family members in the harvest of their crops in different locations, or work on property they owned outside of Nueva Unión.



Nueva Unión nestled in the hillside

## ANALYSIS

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The findings are presented below in the numerical order in which they are outlined in Table 2 (page 6) and are grouped by outcome category and theme. To provide as much detail as possible, data pertaining to each of the 37 indicators is presented. Additionally, a summary of each of the 7 outcome themes is included that highlights the strengths and challenges identified within each.

### 1. OUTCOME CATEGORY: SUSTAINABILITY | OUTCOME THEME: TECHNICAL

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#### Strengths

- The solar energy system and its components have remained in excellent condition.
- System resources were reported to be readily available by the majority of residents surveyed (see indicator 7).
- There is a fairly well-established infrastructure for technical support within the community, through NGO partners, and the local government.

#### Challenges

- While the infrastructure for technical support is well-established, the response and reliability of support resources could be improved.
  - NuSol's partner communities would benefit greatly from an expanded capacity building curriculum that would account for observed shortcomings in the understanding of system operation and performance.
- 

#### *Sub-Theme: Operational Feasibility*

**Indicator 1: System functionality** – Assesses the extent to which the rural electrification system is operating as intended; energy is harnessed and distributed according to the project implementation plan; and mechanical and electrical system components are operating per specifications.

- *System Operational Status:* An evaluation of system energy production confirmed that the solar electric system is operating within expected parameters. Battery charge voltages, kilowatt-hour energy production, battery capacity, and overall system efficiency values were at or above acceptable values.
- *System Components:* Find below a description of the condition of all major system components.
  - *Solar Panels* – All panels are in place, clean, and operational – no signs of damage or unexpected wear and tear. A barbed wire security fence, installed after the departure of the NuSol installation team in January of 2011, is now in place.
  - *Racking* – All module clamps and hardware are in place and operational – no signs of damage or material corrosion. The concrete footing is intact with no signs of cracking or settling.
  - *Solar Panel Combiner Box* – The box is intact and the enclosure lock is in place – no signs of corrosion, wear, or tampering. One of eight breakers was found to be in the open/off position – fault was traced to a loose solar panel conductor.
  - *Panel Wiring* – Because of the open breaker and loose conductor, all panel wiring conductors were inspected – all found to be in good condition.

- *Service/Equipment Room* – This room is regularly locked and kept secure. The moisture levels are low and there are no signs of tampering or theft. It was confirmed that entry remained limited to authorized persons only.
- *Inverter, Charge Controller, and Integration Components* – These were found to be operating within expected parameters, no faults of corrosion. There were some signs of moderate dust build-up.
- *Battery Bank* – The battery enclosure is free of damage or corrosion. The battery enclosure slab is intact with no signs of settling. There is no battery bulging, leaking or corrosion. The NuSol evaluation team re-torqued all battery terminal connections, as three connections were found to be loose. These loose connections were thought to be a result of ambient temperature fluctuations.
- *Charging Station* – All of the charging outlets are functional and free of damage. There was an instance of misuse where a conductor had been run from the communal kitchen to the charging station and plugged in to provide light in the kitchen. The system is able to support this use, but NuSol staff recommended that the municipality complete a more permanent and safe installation of this conductor.
- *Battery SOC (“State of Charge”) Meter* – A digital reading titled “% Batter Charge” was not displayed. This value helps to convey to community members, in simple terms, the amount of energy remaining for use. Although this reading is not required for system functionality, it is an effective method of ensuring that the battery bank is not abused. This fault is likely a result of an unintentional modification of the internal settings by a community member. A solution to repair or replace this component is forthcoming.
- *System Maintenance*: The solar electric system is designed to require very limited maintenance. We were pleased to find that the few maintenance-related tasks the community is responsible for performing were being completed on a regular basis. These are as follows:
  - *Panel cleaning* – Aside from a small amount of dirt build-up in the corners of the panels, they were found to be free of dirt and other contaminants. The community performed regular cleanings by attaching a wetted shirt/cloth to the end of a long pole.
  - *Equipment room inspection* – It was confirmed that approved personnel had been entering the equipment room on a regular basis and performing visual inspections of the power conditioning equipment.

**Indicator 2: System depreciation** – Assesses the wear and tear of the energy system over time and compares its actual condition with expected conditions based on average system lifespan.

- As discussed in Indicator 1, the system inspection indicated that the solar equipment was operating as expected and in excellent condition. Although this is an optimistic sign of continued reliable operation, it is very difficult to assess finite depreciation over a 6-month period when the expected system operational lifespan is 20 years.
- The expected 20-year lifespan has one exception – system batteries. It is forecasted that all 12 gel batteries will require replacement within a 3-6 year period. The variables effecting this replacement date (temperature, depth of discharge, proper charging cycles, etc.) were all found to be within the expected range. Thus, it can be concluded that the system is aging as anticipated.

**Indicator 3: Stable electricity usage** – Assesses energy use patterns within the community and monitors for over-consumption.

- It was found that during cloudier months (February, March & April), there were reports that the system was intermittently not functioning properly. This incident prompted the community leaders to consult with the head of electrification for the provincial municipality, where they were instructed to turn off the main power switch on the system inverter. The community leaders left the system off for one week to allow batteries to return to a state of full charge before turning the inverter back on.
- During the evaluation site visit, NuSol staff expounded upon the importance of establishing a ‘hierarchy of electrical needs’. NuSol staff and community leaders decided that during cloudy periods they are to turn off individual breakers to either the medical post or elementary school to limit energy draw from system batteries, conserving more energy for the charging station.
- In addition to cloudy weather and lack of system operation knowledge, there were reports of abuse by authority figures that likely contributed to the instability of electricity supply. Residents recounted forms of misuse such as the periodic charging of energy-demanding loads like car batteries.

**Indicator 4: Compatibility with future grid services or expansion** – Assesses the off-grid system’s capability to accommodate future expansion and/or linkage with electrical grid expansion.

- Although the solar electric system provided by NuSol was designed with the equipment required for safe and effective grid interconnection, Peru’s power infrastructure is currently not prepared to support such integration in rural areas. Furthermore, the Peruvian Ministry of Energy & Mines (MEM) does not have in place the metering and financial incentives necessary to make this interconnection financially attractive.
- In the event that grid-power becomes available to the town of Nueva Unión, NuSol would recommend that the system be dismantled and moved to another community in need of off-grid electrification services.
- In the event that the power demand within the community is increased, either through the development of needs or the growth of the population, the solar electric system was designed with integration equipment capable of supporting a load twice that of what it is currently carrying. Investment, however, would be required in the form of additional solar panels and potentially additional batteries.

**Indicator 5: Conformance with national/regional/industry standards** – Assesses project’s conformance with best practices in technical performance and installation. This will most likely be addressed in the project development stage

- In Peru, standards for rural electrification through renewable energy are established and regulated by the Ministry of Energy and Mines. However, our partners from the Municipality of Huacaybamba in charge of their province’s electrification efforts were unaware of the specific codes or standards enforced on a national level. The provincial head of electrification projects assisted NuSol during the installation process in Nueva Unión and all of our workmanship/installation methods met with his approval.
- Furthermore, NuSol designed and installed its system to the rigid requirements established by the United States National Electric Code Article 690 – Solar Photovoltaic Systems.

**Indicator 6: Availability of support infrastructure** – Assesses the community’s technical understanding of energy system maintenance and repair and also addresses the proximity/likelihood of professional in-country technical assistance providers (either official or potential partners).

- *Technical support from local government:* Melchor Melgarajo, head of electrification for the Provincial Municipality of Huacaybamba, is responsible for providing ongoing technical support to the Nueva Unión community, as this is his role within the government. Mr. Melgarajo was present during system installation and is familiar with its design and operation. However, communicating and obtaining support from these authorities remains challenging, as the municipal headquarters is a two-hour trip from the community. Additionally, the municipal office does not currently have Internet service and can only be contacted via cell phone or personal visit.
- *In-country NGO partners:* There are a limited number of agencies that maintain a presence in such rural communities. Caritas of Huari, whose offices are located approximately 3 hours from Nueva Unión, is the only other non-governmental partner providing services to this community. Caritas’ efforts are focused on health-related projects, fighting chronic malnutrition, economic development and disaster relief. They do have Internet services in their office and phone contact is fairly reliable.
- *Community authorities:* NuSol staff trained Nueva Unión’s head authority, Hipólito Pantoja (*Agente Municipal*), on how to operate and maintain the solar energy system. He is responsible for conducting any minor repairs to the system in the event that they are needed, i.e. loose wiring, blown breakers, etc. Additionally, NuSol instructed Mr. Pantoja on how weather conditions impact the system’s performance. He is responsible for regulating energy use during months when direct sunlight is not as prevalent to avoid automatic system shut down.

**Indicator 7: Readily available services** – Indicator assesses the ability of the renewable energy system to meet community needs/demands for electricity and light in a timely and reliable fashion.

- NuSol involved community residents in the decision-making process during all stages of project implementation. The townspeople collectively voted on their most urgent electrification needs during communal meetings. These priorities are reflected below:
  - A 25 plug-in charging station located in the communal house (used mainly for lanterns and cell phones)
  - Hard-wired lighting in the communal house in the form of one, 20 W fluorescent bulb (indoors).
  - Hard-wired lighting in the main plaza in the form of one, 20 W fluorescent bulb (outdoors).
  - Hard-wired electricity and light in the elementary school in the form of four plug-ins and two, 20 W fluorescent bulbs (indoors).
  - Hard-wired electricity and light in the medical post in the form of two plug-ins and one 20 W fluorescent bulb (indoors).
  - A rechargeable LED lantern provided to each household in the community that signed up for the project. Fifty-nine lanterns have been claimed of the 70 households in the community at the time of the project’s initiation.
- The household survey asked residents about their use and access to the charging station. Findings are as follows:
  - 32% of residents surveyed say that the charging station is ‘sometimes’ available.

- 68% of residents surveyed say that the charging station is 'always' available.

Reasons the charging station was at times unavailable include:

- Miscommunication about charging station operating hours.
- Household distance from charging station (longer distances act as a barrier to use).
- Financial limitations of residents (inability to pay monthly fee for use).

## 2. OUTCOME CATEGORY: SUSTAINABILITY | OUTCOME THEME: ECONOMIC

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### Strengths

- Over 1/4<sup>th</sup> of town residents use electricity/light to aid in income-generating activity.

### Challenges

- The amount of re-investment revenue collected to date is considerably lower than expected.
  - The availability of electricity/light has not helped in creating new business opportunities within the community.
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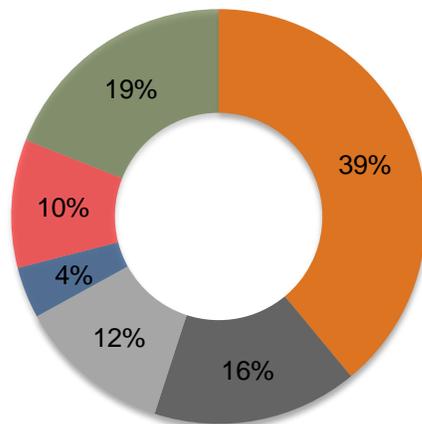
### *Sub-Theme: Financial*

**Indicator 8: Capital and installation cost** – Assesses the finance structure for costs associated with system equipment and installation. To be completely sustainable, partner communities should finance all costs (most likely through micro-lending practices) and initial funders (if they are involved in finance structure) should be completely reimbursed for program related funding.

- NuSol considers the installation at Nueva Unión a pilot project. It is our hope that a successful demonstration of the viability of solar as an alternative to grid expansion in rural areas of developing Peru will attract future in-country financial support from government entities and micro-finance organizations. As such, NuSol carried the majority of the financial burden for this project. A breakdown of these costs and financial investments are shown in the below charts.

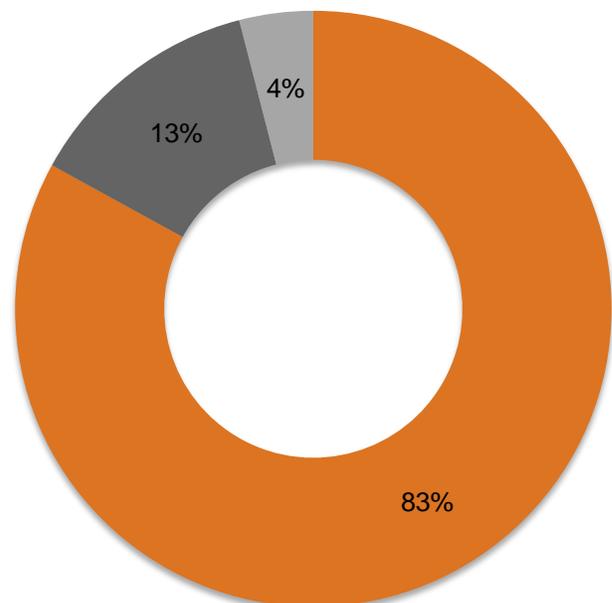
### Project Costs

- Solar Array: panels, racking, integration
- Power Conditioning: converter, inverter, controls, integration
- Battery System: batteries, enclosures, integration
- Power Distribution: outlets, breakers, monitoring, integration
- Rechargeable Lanterns: lanterns, chargers
- Installation Costs: transportation, shipping, etc.



### Project Investment

- NuSol
- Municipality
- Community



- As the above chart shows, NuSol Capacity Fund covered a disproportionate percentage of the project cost. This is unfortunately not a sustainable financial model. Once project viability can be proven, it is our hope that future system costs can be covered via investment from regional governments and micro-lending institutions. Simultaneously, NuSol is applying the lessons learned during this evaluation to design and deploy systems that more effectively address community needs while decreasing costs.

**Indicator 9: Operation and maintenance costs** – Assesses the costs associated with operating and maintaining the energy system. Indicator is closely linked to the performance of indicator 1, system functionality and indicator 2, system depreciation.

- Ongoing system maintenance and operational costs are to be supported by the community members of Nueva Unión via monthly contributions to a collective community account. The majority of these funds will be allocated to battery replacement 3-6 years after installation. See indicator 10 for details associated with this program.
- The cost to replace the battery bank will be approximately \$2,500 USD. Had the community stayed current with their payments, this amount would have been acquired at the end of year 3. The community leader’s inability to successfully organize the fee collection system threatens the long-term operational sustainability of the system.
- However, after observing the operational status of the system and the shallow cycling of the battery bank, it is believed that required battery replacement will likely fall around year 5 or 6, allowing the community a second chance to reinstate a successful fee-collection system.
- Aside from battery replacement, the only other operational costs pertain to unexpected equipment failure. NuSol is prepared to assist with the provision of required replacement equipment to the municipality if this occurs. The local technician will then be responsible for equipment removal and installation. The majority of the equipment designed into the Nueva Unión system is covered by a 10 or 20-year warranty and thus represents a limited financial liability to NuSol.

**Indicator 10: Share of profit set aside for re-investment** – Assesses the extent to which community residents are accumulating savings from which to purchase replacement batteries and/or other system components. A scheduled savings scheme should be monitored through accountability measures decided upon by the community.

- In order to use the system for recharging household lanterns, residents are required to pay S/. 3.00 (Nuevo Soles) per month, approximately \$1.09 USD. This marginal financial contribution from beneficiary community members serves two key purposes:
  1. *Ownership* – Residents take on a sense of responsibility for the system as they are financially invested in its success.
  2. *Financial Sustainability* – Over time, the marginal monthly payments sufficiently amount to cover the cost of anticipated ongoing repairs and battery replacement.
- It was found that a total of S/. 180 have been collected from community members since system installation 6 months prior. This amount is far below projected revenues, which were roughly 7 times greater.
- Reasons why the payment structure has not yielded anticipated revenues are varied and include:
  - *Lack of a paid position* – Collecting monthly payments is the responsibility of select community leaders. However, this task has often been overlooked, as it has not taken priority over other daily tasks. To place greater emphasis on the importance of collecting

payments and increase accountability in this regard, Hipólito Pantoja, the *Agente Municipal*, and Flavio Espinoza, a community leader, will be receiving S/. 10 per month to collect monthly payments and open/close the communal house for lantern recharge and pickup.

- *Lack of local government support* – Contractual obligations between NuSol and the Provincial Municipality of Huacaybamba state that the latter is responsible for assisting Nueva Unión by opening a communal bank account to deposit the household fees collected for system sustainability. However, upon the new government taking power in 2011, they had learned that the local bank had been overcharging the municipality as well as area residents for myriad financial transactions. At the time of system installation, it was suggested that Nueva Unión wait to open a communal account until the municipality had investigated the banking irregularities. Since then, no further action has been taken on behalf of the municipality to assist Nueva Unión in establishing a communal savings account or to conduct any fiscal monitoring of Nueva Unión authorities' fee collection.
- *Seasonal misunderstanding* – During the cloudy months of February, March and April, when the system occasionally shut down due to frequent cloud cover and over-use, many residents stopped making their monthly payments. As the community did not know how to hierarchically allocate the system's energy supply, the system appeared to be depleted or dysfunctional when they attempted to recharge their lanterns. Additional training was given during the site visit to help community leaders better understand the correlation between weather conditions and energy production.
- *System abuse* – In addition to the abovementioned issues, residents recounted forms of system abuse such as the periodic charging of energy-demanding loads like car batteries. These reports of misuse by authority figures likely contributed to the instability of electricity supply, further undermining community confidence in the solar energy supply and thus, the likelihood of making their monthly payments.
- Although re-investment revenues collected to date are far less than anticipated, purchase of replacement batteries won't be necessary for at least 3 to 5 years. Additionally, the technical evaluation of solar equipment has shown the system to be performing at or above expected levels, likely extending battery life further than initially projected, providing ample time to collect revenues for battery purchase.

#### *Sub-Theme: Productive Uses*

**Indicator 11: Percent of electricity consumed by businesses** – Assesses the consumption of energy from local businesses.

- As the focus of this electrification project was rechargeable lanterns for household use and the provision of electricity to the medical clinic and elementary school, NuSol did not anticipate local businesses to report heavy usage of electricity. However, there was one resident that found the lantern to be extremely beneficial to his business, allowing the extension of store hours well into the evening, as light was readily available. As a result, this resident reported a notable increase in sales.

***“With the rechargeable lantern there are less costs for other lighting; we sell more and we're open until midnight or later.”***

– Community Store Owner

**Indicator 12: Percent of electrified households using electricity for income generating activity**

– Assesses household use of electricity as it pertains to income generating activities such as investment in revenue generating resources/equipment (i.e. sewing machine, stove, etc.)

- The majority of residents surveyed (62%) reported no direct relationship between the electricity/light provided and income generating activities.
- More than a quarter of residents surveyed (28%) reported that they did use the electricity/light to aid in income generating activity. For example, the resident whose business was able to stay open later into the evening, thereby increasing revenues. Unfortunately, the evaluation team was unable to collect further anecdotal examples of how residents used the system to aid in income generation.
- It is worth noting that the preceding survey question was most likely understood as ‘economic resources that have been freed up’ as a result of using the rechargeable lantern (and purchasing less traditional lighting resources) rather than direct income generation.

*Sub-Theme: Employment Generation*

**Indicator 13: Businesses developed** – Assesses new business development as a result of reliable access to electricity and/or light.

- There were no new businesses created by community members as a result of the project installation; however, it did contribute directly to the creation of a charging station management job.
- While initially the project scope did not account for the creation of a paid “Fee Collector” position, going forward, Hipólito Pantoja, the *Agente Municipal*, Flavio Aranda, a community leader, will be receiving S/. 10 per month for their duties collecting monthly payments from residents and opening/closing the communal house for lantern pick-up and drop-off.
- With time, NuSol would like to encourage other community members to take on this role or create a rotating schedule where responsibility is shared, thereby increasing the transparency and accountability of the lantern distribution/charging process.

### 3. OUTCOME CATEGORY: SUSTAINABILITY | OUTCOME THEME: SOCIAL/ETHICAL

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#### Strengths

- Since the installation of the solar electric generating system, 100% of townspeople have access to electricity/light.
- 80% of households are in possession of a functioning rechargeable LED lantern.
- The town medical post, elementary school and communal house have electricity/light.

#### Challenges

- It was found that three residents' rechargeable lanterns had broken since system installation.
  - Replacement lanterns can be purchased from the municipal electrician, Melchor Melgarejo, two hours away in the Huacaybamba Municipal building for S/. 15. This represents both financial and geographic barriers to residents acquiring replacement lanterns.
  - The local government has not supplied the medical post with any specialty equipment requiring electricity nor does the elementary school have any teaching aids, aside from light, requiring electricity.
  - Public lighting on the town square has received both positive and negative reviews by residents.
  - There are no micro-credit institutions serving the residents of Nueva Unión.
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#### *Sub-Theme: Equitable Distribution*

**Indicator 14: Percent of community with access to light** – Assesses the percent/share of community households with access to light. During project development, the extent to which light will be distributed will be decided based on community needs and organizational capacity to provide the service.

- All community members (100%) have access to light as a result of NuSol's system installation providing public lighting in communal areas. Residents not contributing their monthly fee for lantern use are still able to benefit from the public lighting.
- Approximately 80% (56 of 70) of households have a personal lighting source through the use of rechargeable lanterns.
- Originally 59 lanterns were distributed, however it was found that three had broken since the installation.
- The community of Nueva Unión was comprised of 70 households when NuSol conducted the initial site visit and socioeconomic survey in 2009. By the installation date in late 2010, the community had grown by two additional households, which NuSol did not account for, and is thus not reflected in this evaluation.
- Prior to system installation all 70 households had signed up to be a part of the Peru Solar 2010 project. However, since residents of Nueva Unión are primarily

- **100% of residents have access to public lighting.**

- **80% of residents have access to personal lighting.**

supported by subsistence agriculture and raising livestock, at any given time some individuals are not present in the community. This is because they are conducting wage labor in neighboring towns, assisting family members in the harvest/planting of crops in different locations, or working on property they own outside of Nueva Unión. This absence affected the number of lanterns that were claimed by residents during installation in 2010.

- Additionally, a number of other townspeople had lost interest in being a part of the project, had since moved away, or did not have the S/. 15 to cover the one-time fee for the lantern.
- NuSol communicated to all residents and local authorities that the unclaimed lanterns would be available for purchase/pick-up in Melchor Melgarejo's office in the Provincial Municipality building Huacaybamba.

**Indicator 15: Percent of community with access to electricity** – Assesses the extent to which distribution of electricity services reach all community households. During project development, the extent to which electricity will be distributed will be decided based on community needs and organizational capacity to provide the service.

- All community members (100%) have access to electricity as a result of NuSol's system installation that includes 25 electrical outlets used for recharging lanterns or other devices requiring electricity (i.e. cell phones).
- Access to the charging station is contingent upon residents making their monthly contribution to the system, thereby ensuring that those who use the system are contributing to the project's long term sustainability.

**100% of residents have access to electricity.**

*Sub-Theme: Availability in Public Spaces*

**Indicator 16: Health centers with electricity and light** – Assesses the extent to which the community health center(s) are provided reliable light and electricity. During project development, the extent to which light and electricity will be provided will be decided based on community needs and organizational capacity to provide the service.

- Prior to the solar electric generating system's installation, there was no electricity within the community medical post.
- The medical post is now equipped with a 20W fluorescent light and one electrical plug-in.
- While the medical post is now capable of operating auxiliary electrical equipment, due to financial limitations within the community and lack of governmental support, the post remains absent of any medical equipment that requires electricity.
- During the site visit, the community's medical technician mentioned the post could benefit from the use of a computer and refrigerator/freezer.



The lighting installed in the medical post

**Indicator 17: Schools with electricity and light** – Assesses the extent to which the community school(s) is/are provided reliable light and electricity. During project development, the extent to which light and electricity will be provided will be decided based on community needs and organizational capacity to provide the service.

- Prior to the solar electric generating system's installation, there was no electricity within the community elementary school.
- The school is now equipped with two, 20W fluorescent lights and two electrical plug-ins.
- While the elementary school is now capable of operating auxiliary electrical teaching equipment, due to financial limitations within the community and lack of governmental support, the elementary school remains absent of any teaching aids that require electricity.
- During the site visit, the community expressed an interest in extending electricity to the kindergarten. It was agreed that the community would petition the local government to provide materials and conduct the installation.

**Indicator 18: Public gathering areas with light and electricity** – Assesses the extent to which public spaces are provided with light, electricity, or subsequent peripheral devices. During project development, the extent to which light and electricity will be provided will be decided based on community needs and organizational capacity to provide the service.

- Prior to the solar electric generating system's installation, there was no electricity in public gathering areas.
- The communal house is now equipped with two, 20 W fluorescent lights that illuminate both the interior of the building and the exterior into the main plaza. Additionally, the communal house contains the plug-in charging station with 25 outlets.
- It was found that a conductor had been plugged into the charging station and run into the communal kitchen on the second floor when light was needed. The NuSol team confirmed that the system could support this additional lighting, but recommended the municipality complete a safer, more permanent installation.
- Residents reported both praises and criticisms regarding communal lighting. Several residents felt the lighting improves safety at night, creates additional social opportunities into the evening, and allows children to play safely in the evening. Other residents felt the lighting in the plaza was too bright and interfered with the sleeping of those living closest to the plaza. Some also felt that because the lighting provided an opportunity for extended socializing, the increased noise created a disturbance.

*Sub-Theme: Credit*

**Indicator 19: Micro-credit options available for renewable energy expansion** – Assesses the extent to which the target community has access to microfinance services for potential energy expansion if desired.

- The financial model for this project did not require the community to collaborate with a micro-credit institution; however, this access would promote future equitability within the community in that all residents have the ability to finance future electrical needs in a sustainable way – independent of external funding.
- There are currently no microfinance opportunities for residents in Nueva Unión.

#### 4. OUTCOME CATEGORY: SUSTAINABILITY | OUTCOME THEME: ENVIRONMENTAL

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##### Strengths

- 63% of town residents reported using the rechargeable LED lantern as their principal source of lighting.
- The electricity provided by the solar array has supplemented the use of a gas generator that was once used by homes around main plaza, thereby saving money and lessening negative environmental impacts.

##### Challenges

- Future projects should consider supplying residents with multiple lanterns for simultaneous use inside/outside the home after dark.
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##### *Sub-Theme: Community*

**Indicator 20: Percent of electrified households where renewable electricity has replaced other energy sources for lighting** – Assesses the extent to which the energy system provided a replacement for traditional forms of energy, such as batteries, firewood, kerosene, etc.

- The rechargeable household lanterns issued in this particular electrification project were not intended to completely replace traditional lighting sources as only one was issued per household. However, when asked what households use most for lighting, 63% of respondents stated the rechargeable lantern.
- During the site visit, it was common that the NuSol team saw residents walking around the town at night with the rechargeable lantern as well as disposable battery-powered flashlights. Residents reported still using the latter for outdoor use, as they often preferred keeping the rechargeable lantern indoors for domestic use.
- Survey respondents reported that women and children used the lantern most often within the household.
- In order to create a more complete substitution effect within future projects, NuSol should consider issuing multiple lanterns per household if residents so desire.

*63% of households have adopted the rechargeable lantern for all household lighting.*

*“It’s [the lantern] brighter than the other things we use for lighting.”*

*– Community Resident*

**Indicator 21: Percent of electrified households where renewable electricity has replaced other sources for cooking** – Assesses the extent to which households have substituted traditional cooking systems with clean renewable energy alternatives. During project development, the extent to which renewable cooking services will be provided will be decided based on community needs and organizational capacity to provide the service.

- While this project did not provide solar equipment that could be used for cooking, it was found in conversations with residents that the lanterns used as lighting aids during night cooking are a safer option to candles or open fires.

**Indicator 22: A unique environmental impact identified** – Assesses the extent to which the renewable energy services provide a unique environmental benefit for the target community. Unique environmental conditions would be identified and addressed in the project development stage.

- Prior to the installation of the solar electric generating system, the community used a gas generator that provided power to roughly a dozen homes around the main plaza and served as an in-community cell phone charging resource.
- It was observed during the site visit that the gas generator is no longer used, as the availability of electricity at the communal house seems to be a more favorable and reliable alternative.
- The substitution from a gas powered generator to clean solar energy represents both financial saving for those who purchased the diesel fuel and also a lessened negative environmental impact from fossil fuel emissions.

*Sub-Theme: Global*

**Indicator 23: Quantity of renewable energy consumed** – Assesses the quantity of renewable energy consumed to demonstrate the local/national/and global impact of the community adopting renewable energy alternatives.

- While energy use fluctuates seasonally, the site visit confirmed that energy production is exceeding consumption. However, without a data logger, exact energy consumption levels are unknown.
- It is estimated that the solar energy system installed is capable of producing 3500kWh of energy annually.
- The NuSol team estimates the community will consume approximately 30% of the system's capacity or 1000kWh of energy within the first year (the equivalent of four, 30W light bulbs running continuously for a year).

## 5. OUTCOME CATEGORY: PROJECT SPECIFIC | OUTCOME THEME: DOMESTIC

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### Strengths

- Roughly 90% of residents surveyed reported an improved brightness in light and reliability from the rechargeable lanterns compared to traditional lighting sources.
- 76% of residents surveyed reported their rechargeable lanterns last longer than traditional lighting sources.
- Nearly 90% of residents surveyed reported an improved indoor air quality and general safety as a result of increased use of the rechargeable lantern and decreased use of traditional lighting sources.
- Nearly half of all residents surveyed reported an increased use of additional electronic devices (mainly cell phones) since having access to a reliable electricity source.
- With the availability of the charging station in the town's communal house, residents have begun to charge their phones daily, no longer waiting till they travel to the main town two hours away.
- As an added social benefit, the community now boasts a television, DVD player, and a 3-in-1 musical device that plays CDs, tapes and the radio— all available for public use in the communal house.

### Challenges

- It was found that residents residing far from the town center were less likely to bring their lanterns to the recharging station and therefore reported them to be less reliable than traditional lighting sources.

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### *Sub-Theme: Household Lighting*

**Indicator 24: Improved brightness of light** – Assesses the extent to which community members acknowledge an improvement in brightness of light as compared to traditional light sources (i.e. fire, kerosene, etc.)

- 88% of residents surveyed reported an improved brightness in light from the rechargeable lanterns as compared to traditional lighting sources.
- 12% of respondents reported no significant improvement in brightness.

**88% of residents surveyed found the rechargeable lantern to be brighter than traditional lighting.**

**Indicator 25: Improved reliability from renewable light**

**source** – Assesses the extent to which community member feel their renewable light source is reliable and readily available. This indicator is closely linked with indicator 7, readily available services.

- 92% of residents surveyed reported improved reliability from the rechargeable lanterns as compared to traditional lighting sources.
- 8% of respondents found either a flashlight or firewood to be a more reliable option.
- It was found that those residents residing farther from the town center were less likely to bring the lantern to the

**92% of residents surveyed found the rechargeable lantern to be more reliable than traditional lighting.**

recharging station and therefore found it to be less reliable than traditional lighting sources. **Indicator 26: Improved duration of light from renewable light source** – Assesses the extent to which renewable light alternatives provide an extended duration of light as compared to traditional lighting sources.

- 76% of residents surveyed reported the rechargeable lantern provided improved duration of light as compared to traditional lighting sources. An additional 3% of respondents reported the lantern, supplemented by traditional lighting sources provide the most duration.
- The remaining 21% of residents claimed flashlights, candles, and/or firewood to have a longer duration.
- Those that recharge the lantern regularly and properly are most likely to find the duration of light to be superior to traditional sources.
- One theme that came up during this portion of the survey is the idea of scarcity, or the availability of resources. One resident claimed, “I have lots of firewood,” in justifying why the light from firewood is superior to the performance of the lantern. Incorporating this economic principle into capacity building curriculum could prove useful for future beneficiary communities.

*76% of residents surveyed found the rechargeable lantern to provide improved duration of light.*

*Sub-Theme: Quality of Living Environment*

**Indicator 27: Improved air quality within households** – Assesses the extent to which community members acknowledge an improved air quality within their households as a result of adopting renewable energy and lighting sources. This indicator is closely linked to the Environmental theme within the Sustainability category, indicators 21-24.

- 84% of residents surveyed reported an improved indoor air quality as a result of increased use of the rechargeable lantern and decreased use of traditional lighting sources.
- Residents specifically cited a noted reduction of smoke within the household. Over time, the improved air quality will aid in reducing respiratory illness, especially for women and children in the community, who typically spend more time indoors.

*82% of residents surveyed reported an improvement in indoor air quality.*

*Sub-Theme: Household Safety*

**Indicator 28: Improved safety within households** – Assesses the extent to which community members recognize an improvement in household safety as a result of adopting renewable lighting and energy alternatives.

- 90% of residents surveyed reported improved indoor safety resulting from the use of the rechargeable lantern.
- Residents stated that the rechargeable lantern is favorable for indoor use as it does not catch household items on fire, cause burns, or other potential disasters. Those surveyed expressed a decreased feeling of stress knowing that these potential dangers were eliminated with the use of the rechargeable lantern.

*90% of residents surveyed reported improved indoor safety.*

### *Sub-Theme: Efficiency*

**Indicator 29: Increased availability of time for other household tasks** – Assesses the extent to which community members feel they have an increased availability of time that can be dedicated to other household tasks as a result of adopting lighting and energy alternatives. (Targeted more towards individuals that maintain the household) This indicator is linked with indicator 7, readily available services, and indicator 26, improved reliability from renewable light source.

- Nearly 85% of residents surveyed reported an increased availability of time for other household tasks as a direct result of the solar energy system.
- However, based on the qualitative responses, it appears the survey question was misunderstood as residents explained the way the lantern is used as opposed to the time they have gained as a result of readily available electricity.

### *Sub-Theme: Information dissemination and communication*

**Indicator 30: Increased use of periphery devices within households** – Assesses the extent to which community members have adopted the use of external electronic devices not provided by the installation team, but as a result of the availability of electricity. Devices could include computers, TVs, radios, etc.

- 44% of residents surveyed reported an increased use of periphery electronic devices as a result of having access to a reliable electricity source.
- The most common device used outside of the rechargeable lantern is a personal cell phone. With the availability of a charging station in the town center, residents can charge their phone daily, no longer having to wait until they travel to the next largest village two hours away.
- The community has also seen the introduction of a television, DVD player, and a 3-in-1 musical device that plays the radio, CDs and tapes – all available for public use in the communal house.

***44% of residents surveyed reported the use of periphery electronic devices as a result of readily available electricity.***

## 6. OUTCOME CATEGORY: PROJECT SPECIFIC | OUTCOME THEME: PRODUCTIVE

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### Strengths

- Over 60% of households surveyed reported a decrease in energy-related expenditures since using the rechargeable lantern.

### Challenges

- Most residents saw no increase in household revenue, as no new businesses were created because of the project. However, the majority of residents experienced a decrease in monthly expenditures on energy related resources, therefore increasing their monthly purchasing power.
  - In future visits and projects, NuSol will examine how residents allocate the money conserved each month as a result of renewable energy.
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### *Sub-Theme: Household Financial*

#### **Indicator 31: Decrease in monthly household expenditures on energy related resources –**

Assesses the extent to which community members are able to increase their purchasing power by minimizing their expenditures on traditional light and energy sources through the use of renewable alternatives.

- Nearly 63% of residents surveyed reported a decrease in household expenses on energy related resources as a result of adopting the use of the rechargeable lantern.
- Residents cited the thriftiness of the lantern's payment structure and the lack of having to purchase candles and batteries in support of their response.
- In future visits and projects, NuSol would like to examine how residents choose to allocate the money conserved each month as a result of renewable energy.

**Nearly 63% of residents' household expenses on energy related resources decreased.**

**Indicator 32: Increase in monthly household revenues –** Assesses the extent to which community members see an increase in their household revenues as a result of the adoption of renewable energy alternatives. This indicator is closely linked with the Sustainability category's Economic Theme, indicators 12-13.

- On a communal scale, most residents did not see an increase in revenue, as no new businesses were created as a result of the project; however, the majority of residents experienced a decrease in monthly expenditures on energy related resources (see indicator 31 above).
- One resident with a local store did report increased sales as a result of being able to stay open later into the evening with the use of light provided by the rechargeable lantern; though, it is uncertain the degree to which revenues increased.

## 7. OUTCOME CATEGORY: PROJECT SPECIFIC | OUTCOME THEME: PUBLIC

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### Strengths

- Nearly 34% of residents surveyed reported an increase in their children's time spent reading/studying in the evening as a result of the rechargeable lantern.
- Their local infrastructure is currently capable of accommodating electronic resources, as both the elementary school and medical post are equipped with lights and plug-ins that could be utilized to power medical devices and teaching aids.
- Public lighting has been met with positive reviews that claim it provides a space for socializing at nighttime.

### Challenges

- NuSol acknowledges the potential for the presence of the interviewer to have influenced the interviewees' responses in regards to children's increased/decreased reading time. Interviewees may have perceived a certain desired outcome on behalf of the interviewer and catered their answers to meet that expectation.
  - Public lighting has also been met with negative reviews. Some claimed that the brightness of light and late night socializing keeps nearby neighbors awake at night.
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### *Sub-Theme: Education*

**Indicator 33: Increased time spent reading** – Assesses the extent to which youth spend more time reading after dark as a result of the adoption of renewable energy alternatives. This indicator is closely linked with indicators, 7 and 26.

- Nearly 34% of residents surveyed reported an increase in their children's time spent reading/studying in the evening as a result of the rechargeable lantern.
- NuSol is cautious in presenting an average time dedicated to reading/studying as respondents gave responses inconsistently in both average time & increased time spent reading/studying. Responses ranged from a total of 30 minutes to an increase in two hours of time that children spent reading/studying as a result of the rechargeable lantern.
- NuSol also acknowledges the likelihood that interviewer presence may have influenced interviewee responses. Particularly in this topic, residents may have desired to demonstrate to the evaluation team their use of the lantern to benefit their child's education. In doing so, they would cast themselves as parents and their children as students, in a positive light.
- Nonetheless, NuSol is pleased to see residents reporting the use of the rechargeable lantern for educational purposes within the household and will continue to find ways to emphasize this habit in capacity building curriculum and community planning discussions in the future.

**34% of households reported an increase in their children's time spent reading at night.**

**Indicator 34: Infrastructure capable of accommodating electronic teaching resources –**

Assesses the extent to which schools are equipped with the infrastructure that would allow the introduction of electronic teaching resources. This indicator is linked closely with indicator 18, schools with electricity and light.

- As seen above in indicator 18, the community elementary school is equipped with hardwired lighting and two electrical outlets. While the community does not currently have any dedicated electronic teaching aids, the school itself is capable of accommodating their use at any moment.
- As mentioned in indicator 30, the community does jointly share a TV, DVD player, and musical device capable of playing the radio, CDs, and tapes. In the event the community does acquire educational media, the infrastructure to host this content is in place, even though it is currently used primarily for entertainment.

*Sub-Theme: Health***Indicator 35: Infrastructure capable of accommodating more advanced medical resources –**

Assesses the extent to which medical facilities are equipped with the infrastructure that would allow the introduction of advanced medical resources requiring electricity. This indicator is closely linked to indicator 17, health centers with electricity and light.

- During the site visit, the community's medical technician was on a leave of absence and had left the medical post locked to ensure the safety of the medical equipment inside. As the technician is the only person with access to this building when it is locked, the evaluation team was unable to inspect the inside where lighting and electrical outlets had been installed.
- While the community does not currently have medical equipment requiring electricity, the medical post is equipped with electrical outlets capable of accommodating refrigeration or other basic medical devices.

*The community medical post is capable of accommodating refrigeration and other electrical medical equipment.*

*Sub-Theme: Community Development***Indicator 36: Improved public lighting –**

Assesses the extent to which community members feel public spaces have improved lighting as a result of the adoption of renewable energy alternatives. This indicator is closely linked with indicator 18, public gathering areas with light and electricity.

- The community plaza is equipped with public lighting.
- As explained in indicator 19, the public lighting provided in the town center received a mixed reception. Residents find it to be both a safety improvement and a means of extending socialization opportunities into the night, as well as somewhat of an inconvenience that creates intrusive lighting and increased noise levels during the night that disproportionately affects nearby households.

**Indicator 37: Improved/development of community security** – Assesses the extent to which community members feel an increased sense of security due to the adoption of renewable energy alternatives. This indicator is closely linked with indicator 19, public gathering areas with light and electricity and indicator 37, improved public lighting.

- Unfortunately, this indicator was not directly incorporated into the household survey or individual interviews conducted with residents.
- While input was not solicited on this topic, NuSol believes the portable rechargeable lanterns and public lighting in the town plaza are both resources that improve community security as they enhance visibility in the evenings.

## CLOSING SUMMARY

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The findings from the 6-month evaluation of NuSol's pilot project in Nueva Unión demonstrate the presence of a number of sustainability criteria and other positive outcomes. While we are pleased to see these successes, from a program development perspective, we are equally excited to learn from our mistakes. By evaluating and critiquing our efforts, we've gained an incisive look at the real world performance of our project design and implementation strategy. This analysis provides the basis from which future program and design improvements will be made. What follows is a summary of the lessons learned and a look at how NuSol is incorporating these findings to improve its rural electrification program.

### **Government and In-Country NGO Partnerships**

One of the most critical elements in the successful implementation of a project is the viability of the authorizing environment. In the context of our projects, NuSol recognizes the need for a greater level of involvement and support from collaborating governments. One salient example: NuSol found the provincial municipality unable or unwilling to comply with its contractual obligations to assist and monitor Nueva Unión's fiscal responsibilities for system maintenance. In future endeavors, NuSol will work with partnering governments more closely to guarantee that necessary financial savings mechanisms and monitoring schedules are in place prior to system installation.

NuSol also recognizes that the financial stability of future electrification projects rests heavily on the involvement of microfinance institutions (MFIs). In addition to offsetting initial installation costs, access to financing will allow residents the ability to leverage newly available electricity via investments in entrepreneurial endeavors and community resources. However, as the beneficiary communities NuSol aims to serve are extremely rural, it is often the case that MFIs have yet to establish a presence. NuSol will actively seek out communities that are served by MFIs and advocate for their involvement in partnering communities that have yet to receive such services.

In the event that local governments are unable to provide the equipment and training required to effectively capitalize on the presence of an electrical resource, NuSol will continue to pursue the involvement of partnering NGO's in future projects. As was the case with Nueva Unión, we found that provision of power to the clinic and school was of little benefit in the absence of equipment such as vaccine refrigeration, projectors, or computers. Providing a reliable power source is only the first step; leveraging that power in a manner that effectively addresses community needs is a task that requires a collaborative effort between NuSol and other NGO's operating in rural Peru.

### **Project Design**

Our evaluation revealed project design aspects that functioned as intended as well as those that failed to meet performance goals. One area NuSol will be directing increased efforts is in the improvement of the capacity building curriculum delivered to community technicians. Technicians receiving formal, rigorous training from the onset of project installation will aid in system reliability and sustainability through the effective management of system use, proper completion of maintenance activities, and timely repair of unanticipated equipment failures. The successful completion of these tasks will bolster community confidence in the system's dependability, ensuring that maintenance payments are made on time.

Another area where future projects could be more effective is in the election of authority figures that oversee the system charging station and fee-collection process. As NuSol received verbal complaints of authority abuse, mainly by community leaders to charge their electronic devices, community members should vote on the person(s) responsible for the charging station instead of defaulting to the pre-existing authorities. Additionally, as per resident suggestion, this post should not be held indefinitely, but rotate after a length of time determined by the townspeople to increase accountability and transparency.

Although the solar electric system in Nueva Unión is performing as expected, NuSol believes it can make several technical improvements to increase the performance of future systems. Paramount among these changes is the automation of load control and incorporation of system intelligence. Since a solar electric system relies directly on local weather patterns, load use also needs to correlate directly to the often inconsistent availability of sunlight. The residents of Nueva Unión had difficulty understanding this connection, resulting in the excessive depletion of the battery bank several times through the winter months. Historically, systems have been oversized to accommodate this variability, ensuring that all loads operate all the time. However, NuSol believes it can dramatically cut system size, and cost, by automatically turning on, and off, non-vital community loads based on continuous monitoring of the battery bank, solar array input, and local weather patterns. NuSol is currently engineering a prototype system, which incorporates this feature and hopes to deploy a pilot project in early 2012.

Another project aspect for which NuSol is developing new ideas based on evaluation feedback is the monthly payment structure for lantern use. Instead of paying a flat monthly fee, residents may find it more useful if they had the option to pay for services as they are needed (a pay as you go idea is already broadly understood through cell phone use). In this way, residents would pay a nominal fee for every recharge of his/her lantern. The fee collector would receive a portion of each recharge fee and deposit the rest in a communal fund for battery replacement and system maintenance. This system would create a financial incentive to collect/return as many lanterns a day as possible, and also promote entrepreneurship as the fee collector could charge additional fees for lantern “delivery” to those living far from the charging station.

## **Domestic/Social**

An issue revealed through the evaluation was the potential misuse of the solar system through excessive use of a TV and DVD player located within the community center. Although this kind of social and entertainment use may outwardly seem secondary when compared to meeting more basic health and education needs, studies have shown that access to TV, radio and music players are of notable importance to individuals living in rural communities. These resources help strengthen social ties and encourage cultural inclusion on both a local and national level. Although NuSol’s primary goal is the provision of electricity for fundamental quality of life/infrastructure needs, through increased system intelligence, mentioned above, we hope to continue to support the periodic and responsible use of such devices.

## **Analytical**

While this evaluation proved extremely informative, NuSol has identified ways to improve its effectiveness. As the development of our evaluation framework was completed post-project installation, the baseline survey administered was not directly comparable to the evaluation findings. To ensure an accurate pre/post analysis, future beneficiary communities should be given a baseline survey that correlates with the basic electrification/quality of life indicators outlined in the program

evaluation methodology. In conjunction, NuSol must ensure evaluation questions are understood completely and address the level of detail the evaluation methodology outlines. For example, residents seemed to be confused when asked about reading habits and even if a time figure was provided, there was no baseline data from which comparisons could be made. Also, breaking questions down into male/female categories as well as by age groups would be beneficial. Another evaluation area needing greater attention is how residents choose to allocate the money previously spent on traditional lighting resources. While savings are widely cited, our team was unsure how these funds were reallocated.

Lastly, given the presence of community authorities, during both the communal survey and individual household interviews, it is understandable that many residents were apprehensive about voicing personal criticisms of authority figures. However, the NuSol team did receive various informal, verbal complaints about authority abuse of the charging station in private. Providing a one-on-one component to each survey would help create an environment where an interviewee would feel more comfortable expressing potentially disapproving remarks about a community authority.

We hope this evaluation provides a deeper insight into our work. While we are pleased with the outcomes from our pilot project, we remain focused on improving our ability to meet the needs of those still living without access to reliable electricity.

For a brighter future,

## The NuSol Team

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