Poverty Reduction in Panama:

Reducing the use of disposable batteries in a Ngöbe village

Energy Resources Group 291: Design for Sustainable Communities

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Executive Summary

For families living in poverty, every dollar is significant. Every dollar can represent the difference between hunger and nourishment, bare feet and shoes. One way to reduce poverty is to reduce the cost of living. A path to poverty reduction, therefore, is to examine what technologies are used by the poor, and make them more affordable. Introducing a technology that will save families money will increase their disposable income, and hence their access to life's essentials.

This is where a dedicated group of students can do a great amount of good. With this in mind, we challenged ourselves to develop a project for decreasing the cost of light. A successful lighting innovation could ultimately reduce the cost of living in impoverished villages. We chose to focus on a village where a team member had experience as a year-long volunteer: Soloy, Panama.

Soloy is unelectrified. We found that families in Soloy spend a large portion of their income buying disposable batteries to power flashlights. If we reduce the amount of batteries that are bought, we increase disposable income. Thus by making the flashlights significantly more efficient, we have an effective poverty reduction program.

Our strategy for increasing flashlight efficiency is simple. The flashlights that are currently being used have an incandescent-type bulb. Such a bulb is grossly inefficient, especially compared to the latest technology, white light emitting diodes (LED). We therefore decided to retrofit the flashlights already used by community members with the efficient LED bulbs. This has the potential to save families $63 or more per year, as we will demonstrate. This is a significant saving in a region where people typically live on $1 -$2 a day.

In order to further economically empower the people of Soloy, we propose to have the LED retrofits assembled in the village. This will provide entrepreneurial and employment opportunities. This project is not just about reducing battery use: it is about empowerment.

Though we are focusing our initial efforts on a specific village, this technology can have a global reach, for approximately 25% of the world's population lives without electricity, and must rely upon other forms of lighting, such as battery powered flashlights. If we launch a successful campaign in Soloy, there is great potential for expansion.

Project Background and Context

Target Community

In many parts of the world, indigenous people live on the fringe of society, with a lower social, economic and political status than that of their fellow citizens. The indigenous people of Panama have been subjected to such inequity for hundreds of years. Although Panama has enjoyed some industry and income from the Panama Canal, that wealth has not manifested itself in the indigenous population, who largely continue to live in rural areas with little access to health services, education, employment, clean water, and electricity.

Figure 1: Comarca in Panama

The Ngöbe people are the largest of eight recognized indigenous groups in Panama. The Ngöbe live in a mountainous territory called the "Ngöbe-Bugle Comarca", which was just granted semi-autonomous status in 1997. The location of the Ngöbe Bugle Comarca in Panama is shown in Figure 1. The total population of the Ngöbe Bugle Comarca is 115,000 people of both the Ngöbe and Bugle groups, according to the 2000 census. The Ngöbe and the Bugle people have similar traditions, but are distinct ethnic groups with different languages. The majority of people living in Soloy speak or understand some Spanish; however, their native language is Ngobere.

Figure 2: Besiko District in Comarca

The population is dispersed within the vast area of the Comarca. Primary income sources include agriculture, migrant labor, and crafts. Throughout the Comarca, infrastructure such as schools, health clinics and roads are scarce; most of the Comarca is only accessible by foot. Compared to the nation as a whole, the Ngöbe have extremely high rates of illiteracy, childhood malnutrition, and exposure to infectious diseases, as can be seen in the data summarized below in Table 1 (from the 2000 Panamanian Census):

	Ngöbe-Bugle Comarca	Panama
Population	115,000	3.2 million
Percent of population under 18 years	60%	30%
Average annual income	$500	$1500
Percent illiterate	46%	7.6%
Rate of childhood malnutrition	50%	22%

Table 1: Comparison of Ngobe-Bugle and Panama

These people face many hardships, and not least among them is limited access to energy resources. Because there is no electricity, lighting is an oppressive economic drain. Candles and kerosene are used indoors at night, and flashlights are heavily relied upon for both indoor tasks and travel by foot. Many people rely on flashlights to travel long distances to reach their families, farms, or schools, mostly along unlit forest paths. Unfortunately, these flashlights utilize such inefficient incandescent bulbs (~5

lumens/watt) that the batteries exhaust after only a few hours. LED bulbs have a much higher efficiency (~25-75 lumens/watt), meaning a bulb retrofit would drastically extend the longevity of each battery. Currently, an average family spends at least $1/week – 10% of their income – on batteries. An LED retrofit would mean purchasing batteries would not have to be such a huge economic burden. This project would be beneficial for all involved – the residents spend less time and money purchasing and replacing batteries, there is less overall disposal of batteries, and the project will be self-sustaining by using locals to assemble retrofits and run the business.

We have therefore decided to empower the citizens of a Ngöbe village to reduce their battery dependence. We are focusing on the village of Soloy, which has a population of 2,500. Soloy is one of the better serviced villages in the Comarca, with a fairly accessible road, a radio station and a school. The school is unique in the Comarca in that it has an internet lab, powered by solar panels. Being able to be in contact with members of the community through the internet lab has proven invaluable in this project. This and Soloy's other infrastructure makes it a good place to launch a campaign.

Project History

Our team consists of two members from the Spring ERG 291 class: Kimberly Lau and Anna Zaniewski. Kimberly is a graduate student in Mechanical Engineering, and Anna is a graduate student in Physics. In 2005, Anna volunteered for a year in Soloy, Panama. In that time, she taught English and built a network of contacts with members of the community. She helped local community member Adan Bejerano Rios develop a grassroots organization called Medo which has the objective of supporting sustainable development projects in the community. This is the primary organization we are working with.

Figure 3: Anna Zaniewski and Kimberly Lau, with flashlight

We started this project from scratch. This opportunity afforded us great freedom and flexibility, but also produced many challenges. In the beginning of the semester, we considered several focuses for our group, ranging from small power generation to what we ultimately settled upon, reducing battery dependence by increasing flashlight efficiency.

Throughout the course of the semester, our goals have changed with the focus of our project. The goals we defined in the semester are as follows, and have since been achieved:

- Develop prototypes of LED retrofitted flashlights and maximize design with respect to user needs
- Identify financially viable means of distribution of LED retrofits
- Design specifications of retrofit kit
- Performance analysis of battery lifetime with LED flashlight
- Economic analysis with models of distribution
- Pilot test of prototypes
- A manual on how to retrofit flashlights; pilot test the manual

We will discuss these goals, what we accomplished, and any issues we encountered.

Lighting Technology

The Ngöbe people currently use incandescent flashlights, kerosene, and candles to produce light at night. This light is used for walking, cooking, working, reading, and other nighttime tasks. Table 2 gives an overview of the brightness and costs of these light sources.

Type of Lighting	Light supplied	Initial Cost	Averaged operating cost for 1hr
Solar Panel	~50 lux	$150	0.03
Incandescent Flashlight (with Carbon Zinc battery)	~2000 lux	$1	0.12
3 LED flashlight	~50 lux	$3	0.01
Kerosene	~50 lux	$5	0.06
Candles	~10 lux	$0.10	0.03

Table 2: Statistics for Different Light Sources

A lux quantifies the intensity of light, and is equal to the illumination of a surface one meter away from a single candle. An average person is able to see in a range of 0.00005 lux to 100,000 lux.

The majority of the Ngöbe people use a standard, plastic D-cell flashlight without the extra luxury features (waterproof casing, alarm capabilities, etc). The batteries available for purchase in Soloy are carbon-zinc and alkaline D-cell batteries. Unfortunately, these disposable batteries run out quickly when used to power incandescent bulbs, forcing the residents to replenish the battery supply very often.

The Ngöbe people mainly use flashlights, kerosene, and candles to produce light. Our immediate goal is to maximize the battery life by retrofitting current incandescent bulbs with more efficient LED bulbs. Since incandescent bulbs have a low efficiency of ~5 lumens/watt compared to that of LED bulbs (~25-75 lumens/watt), a retrofit would drastically change the longevity of each battery. This project is beneficial for all involved – the residents spend less time and money purchasing and replacing batteries, there is less overall disposal of batteries, and the project will be self-sustaining by using locals to continue retrofits and running the business.

Retrofit vs New flashlight

Theoretical evaluation of technology: Incandescent vs LED type bulbs, battery characteristics

According to a pilot survey, incandescent flashlights are used in the community for walking, cooking, working, reading, and other nighttime tasks. The standard flashlight used is a plastic D-cell flashlight. The only batteries available for purchase in Soloy are Tiger zinc-chloride and Panasonic alkaline D-cell batteries.

Incandescent bulbs are grossly inefficient compared to technology available today. An incandescent bulb functions by heating up a filament to the point of radiating in the visible part of the electromagnetic spectrum. This is similar to a burner glowing red when heated. Like the burner, the incandescent bulb radiates most of the input energy in the infrared, which we feel as "heat". This means that the majority of the energy that goes into lighting an incandescent bulb is expended in producing heat, rather than visible light.

The most promising alternative for small scale applications, such as flashlights, is the light emitting diode (LED). An LED is made out of a semiconducting material. This material has the property such that with the right amount of energy, electrons are excited out of their lowest energy state into a higher one. The electrons then emit a photon and return to the lower state. These electrons radiate directly in the visible region of the spectrum with little loss to heat. As such, a LED bulb is much more efficient than an incandescent bulb. Different colors of light are achieved through the use of different materials. White LEDs are made with gallium nitride and a small amount of aluminum. LEDs have efficiencies of 5 to 15 times incandescent bulbs.

We can draw even more hours out of the batteries by taking advantage of battery characteristics. Batteries do not have a fixed current capacity: the amount of amp-hours (hours the battery will function at a given current output) out of a battery depends on the load (the amount of current the device draws from the battery). Battery capacity vs load is illustrated below in Figure 4.

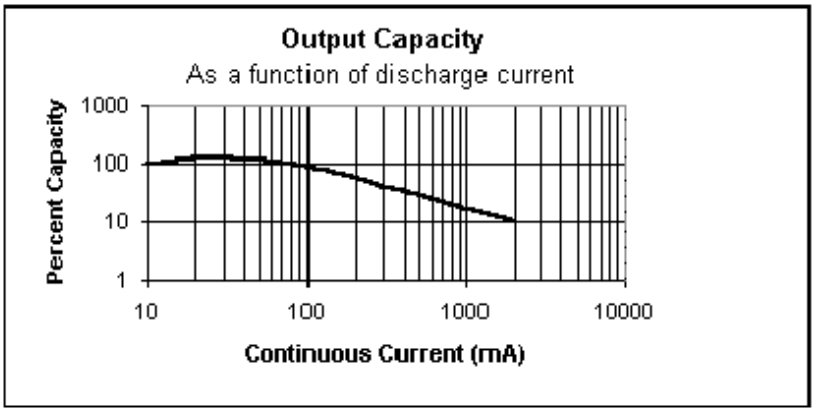

Figure 4: Battery Capacity vs Load

At 500 mA, the typical current draw of an incandescent bulb, the effective battery capacity is around 30%. Conversely, a LED replacement bulb that draws 20-60 mA would yield a battery capacity near 100%.

A 2 bulb LED flashlight would draw 40 mA of current, making the current load ratio of LED to incandescent 40/500=8%. For a given current capacity, batteries powering the LED bulbs would last 12 times as long. However, the capacity dependence outlined above would increase battery lifetime of the LED bulbs over the incandescent by another 3 times, so the expected lifetime of a 2 bulb LED flashlight is 36 times that of a typical incandescent. Based on actual prototypes, the gain is closer to 30 times. With batteries that last 30 times as long, the amount of money that families spend on batteries will shift from a huge economic burden to an occasional, affordable purchase.

At this point, a major disclaimer is necessary. The "LED replacement bulb" referred to above would not output as much light as the incandescent. It is possible to output equal light with LEDs as achieved with incandescent bulbs, but the advantage of using an LED bulb over an incandescent bulb would be around 5 times, just the ratio of lumens/watt efficiency of the two kinds of bulbs. We are purposely making our LED replacement flashlight less bright than the incandescent flashlight in order to maximize battery lifetime and minimize initial cost. Of course, before this design is finalized, the LED retrofit will be user tested to ensure that the users are also satisfied with the light output. We have theoretical reasons for believing that the light output of our LED flashlights will be adequate for general use, because of the way the human eye functions, as described below.

The eye responds logarithmically to light. In other words, a factor of 10 difference in the number of photons hitting the eye appears as a factor of 2 difference in brightness. This enables humans to see in a wide variety of lighting conditions: from bright sunlight to clear starry moonless nights. Thus, it is our conclusion that the incandescent flashlight provides much more light than is necessary. With eyes adapted to the darkness, a 2 bulb LED flashlight illuminating is sufficiently bright. See Table 3 for a numerical comparison.

Starlight	0.00005 lux
Moonlight	1 lux
Candle at a distance of 30 cm (1 ft)	<10 lux
2 bulb LED flashlight	~40 lux
Family living room	50 lux
Bright office	400 lux
Incandescent flashlight	~2000 lux
Sunlight on an average day	100000lux

Table 3: Numerical Comparison of Lighting Conditions

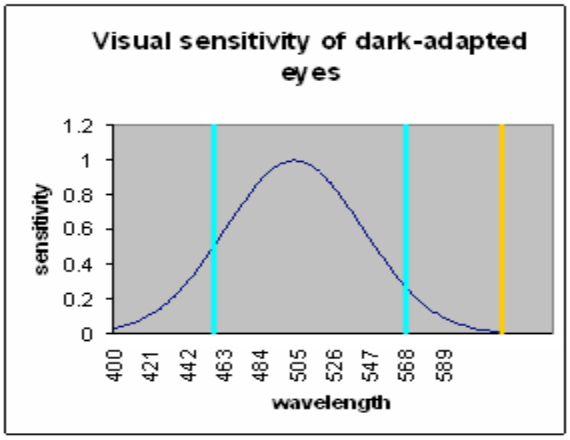

Figure 5: Visual Sensitivity of Eyes

There is one additional consideration to make about the human eye response to light: the wavelength (or color) dependence. The eye responds differently to different colors, and is more sensitive to some colors than others. In dark conditions, the eye is most sensitive to wavelengths near 500nm, which is a blue-green color. A flashlight sized incandescent bulb has a peak wavelength near 630 nm. This corresponds to the familiar yellow-orange color of incandescent light. White LED light has double peaks near 460 and 570nm. Thus, white LEDs come much closer to the peak of visual sensitivity than do incandescent bulbs. See Figure 5 for a graphical representation of visual sensitivity and for pictures of beam output of the incandescent and our LED bulb.

Prototype evaluation

We have performed several tests to verify the usability of our prototypes. We have run light output experiments at LBNL (Lawrence Berkeley National Lab), where we measured the flux of light hitting detectors 30 cm away, with three flashlight types (2-LED, 3-LED, incandescent bulbs) left on continuously. These tests are important because they help us determine battery lifetime for the different flashlight types. The data can be analyzed to gain a worst case scenario of light output versus time. This is the worst case scenario because the experiment does not accurately reflect use; the flashlights

were left on continuously, whereas normal use would include turning them on and off. A 1.5 V battery will drop in voltage during use, but will regain most of its initial 1.5 V once it is disconnected from the circuit. It is the current capacity, not the voltage, that is being exhausted.

The results of the tests are shown in Figure 6. Note that the intensity of the incandescent and the LED bulbs are plotted with different scales. This test was done using zinc-chloride type D cell batteries in our prototypes. An identical test was also performed using alkaline batteries, pictured in Figure 7Figure 6.

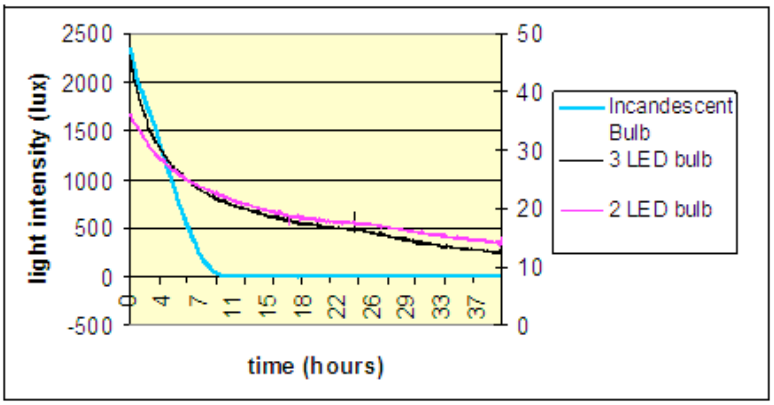

Figure 6: Light Intensity vs Time (hours), Carbon Zinc batteries

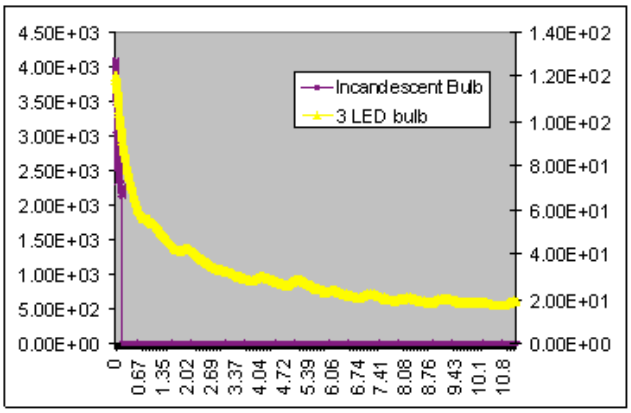

Figure 7: Light Intensity vs Time (days), Alkaline batteries

Note that the sudden drop-off of the incandescent light output in Figure 7 is due to the incandescent bulb burning out four hours after the test began. This demonstrates another advantage of our product – the LED bulbs will last for thousands of hours more than the incandescent bulb.

The results of the first test (Figure 6) show that the battery powering the incandescent bulb was exhausted after ~9 hours. The LED lights stayed on for ~2 weeks continuously (data not pictured after 40 hours) with the carbon-zinc batteries, and even longer with the alkaline. In actual use, the light output of the LEDs should remain fairly constant over the lifetime of the battery, and decrease when the battery can no longer recover its original voltage. We will utilize surveys to determine actual battery lifetime with typical use.

For a visual comparison of beam intensity and shape, we took pictures of the light beams for incandescent and LED bulbs using identical camera settings and a shutter speed of 1/3-second, shown in Figure 8. This picture demonstrates how bright the incandescent bulb beam is – too bright. This intensity will cause the pupils to contract, making it more difficult to see dimly lit objects in the night and therefore limiting one's vision to the bright incandescent flashlight beam. The dimmer LED bulb will better preserve one's night vision because the output is not as bright. This makes for safer travel at

night, preserving awareness of one's surroundings. Note also that the way a beam looks in a picture is different than how it would look in the field, as the eye and a digital camera respond differently to light levels.

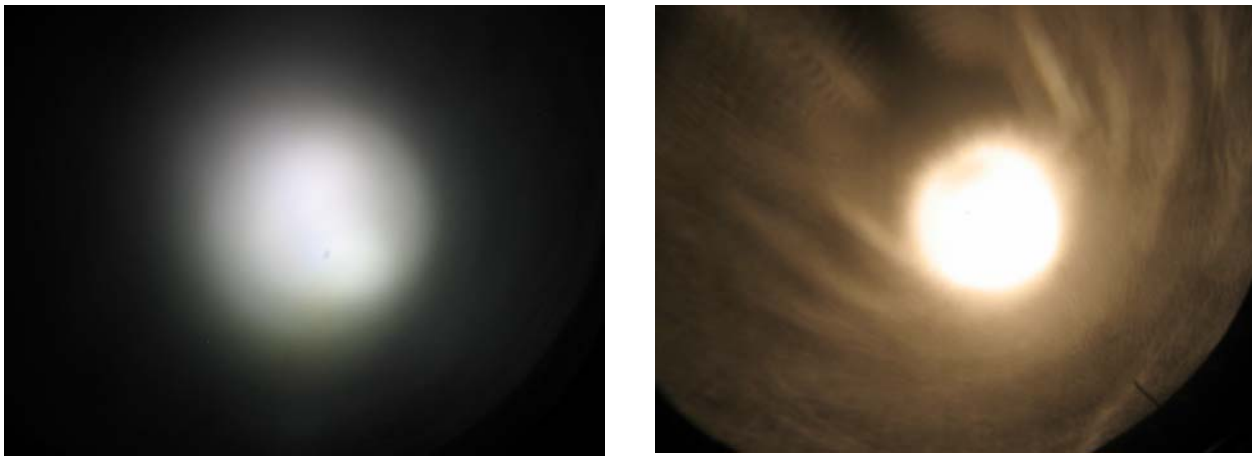

Figure 8: LED bulb vs Incandescent bulb beam

We are testing our prototypes in California and Panama. Team member Anna Zaniewski used a 2 LED flashlight prototype during a week-long camping trip and reports that the beam produced was sufficient for all night activities: walking around, playing cards, and lighting the tent.

Additionally, we have shipped three versions of our prototypes to our local coordinator Adan Bejerano Rios and his family in the Soloy. They arrived over a week ago, and the family reports that they like and use the flashlights to the exclusion of the other flashlights. He wrote (sic):

> My family told me that they better prefer the new flashlight and they agree also that the battery lifetime is longer. One battery that last two days in the old flash it had like a week in the new flashlight you sent and still work fine. So we think that the new flashlight can hold longer the battery we use here in Soloy like for two or three week. Of course it will depend how often we use it. So this is a good news for us. People are willing to pay until 5 dollars minim for a new brand flashlight where the battery can last for a longer period of time. If we can guarantee these possibilities I think it would be very convenient for all fo us.

The entire email is in Appendix I.

Prototyping

It is important in all design projects to develop prototypes of the product to test the concept. In this project, we built a number of flashlight prototypes. To do this, we purchased standard plastic incandescent flashlights and LED bulbs. A soldering iron and solder was also required to successfully meld new and previously existing components of the flashlight. The steps for the retrofit were as follows:

1. Open the flashlight and remove the incandescent bulb
2. Crack open the incandescent bulb and remove all glass so only the metal bulb shell remains
3. Take the LED bulb(s) and solder the positive and negative legs to the appropriate ends of the metal shell
4. Re-screw the bulb into the original slot and close the flashlight
5. Turn on flashlight

The light output of the retrofitted LED flashlights is determined by the number of LED bulbs used. We retrofitted flashlights with one, two, and three LED bulbs. The maximum number of LEDs was three

due to the limited space within the metal casing. The LED bulbs need to be aligned with one another to produce a well-shaped beam. As such, if the bulbs are too cluttered, they will displace one another and create an uneven beam for non-optimal lighting. Initially, the three LED bulb retrofit seemed to produce the best and brightest light. However, as the battery discharges faster for the 3 LED flashlight, the average light output of the two and three LED bulbs is not appreciably different. Furthermore, a 2 LED bulb design is less costly to produce and ensures a longer battery lifetime. The flashlights with just one LED bulb were too dim to be useful for walking at night.

Manufacturing

The process described above for making the prototypes is only acceptable for the manufacture of one or two bulbs at a time and is not easily scalable. The most time consuming aspect of the assembling process is the removal of the glass from the bulb base. As such, a prototype for easily removing the glass from the bulb sleeve was developed, named "The Bulb Smasher".

Figure 9: Bulb Smasher 1.0

Figure 10: Grinding motion of Bulb Smasher 1.0

In previous attempts, we had tried cracking the with a screwdriver head, used like a vertical hammer. However, this method proved to be both laborious and very slow. The impact of our strikes was not great enough to quickly crack the glass, so we concluded that grinding might be more effective, as shown in Figure 10. Additionally, the bulb case was too small to comfortably grasp during the process. This initiated our designs for the Bulb Smasher 1.0, pictured in Figure 9.

This Bulb Smasher is comprised of two parts – a holder for the bulb sleeve, and a screw component for grinding the glass away. The prototype was manufactured in the machine shop, using the lathe, drill, saw and milling machines. The prototype is built from aluminum stock. After completion, the Bulb Smasher was tested on a bulb casing, and successfully and quickly removed all glass from the bulb. This led to designs for Bulb Smasher 2000, which would produce a fast and easy way to remove glass from many bulbs at once. The current designs will fit five bulbs at once, and is pictured in Figure 11.

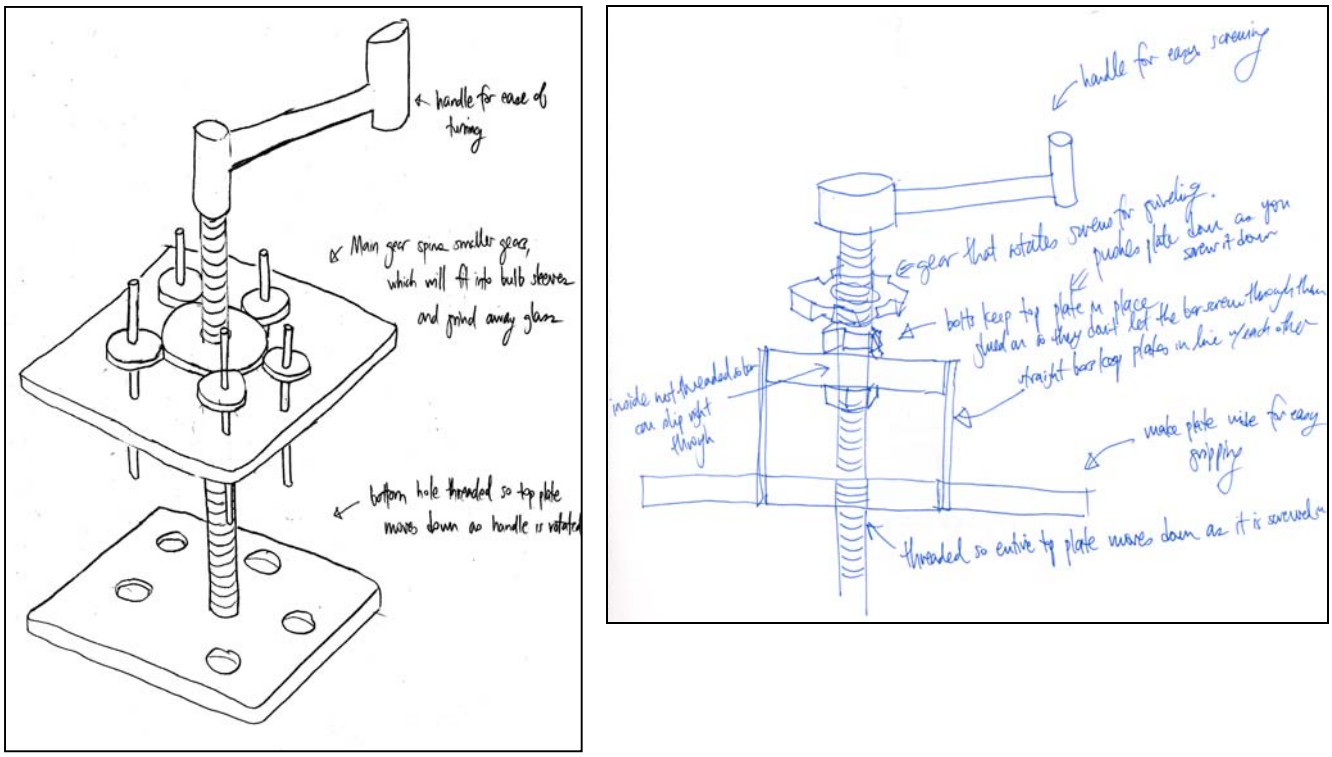

Figure 11: Bulb Smasher 2000

Economic Justification

Members of the Soloy community use a high number of batteries. In an informal survey of twelve community members, we found that they bought, on average, 3.8 batteries/week. Using an average price of $.65 per battery shows that the surveyed community members spend an average of $2.47/week on batteries, with the primary use being for flashlights. However, since this survey only interviewed twelve people, we are not confident in extrapolating to the larger community a cost of $2.47/week on batteries. We therefore estimate a lower limit of $1/week –the minimum reported by the twelve interviewees – on batteries.

We concluded that it would be easiest and most beneficial to introduce a technology that was as similar as possible to the existing technology, with modifications to achieve greater efficiency. Therefore, we considered the distribution of new battery powered LED flashlights and the retrofitting of their own existing flashlights. Since D cells are the most cost efficient batteries in terms of current capacity per dollar and are readily available in the community, we decided to focus on D cell battery operated flashlights.

Unfortunately, the market for such flashlights tends to be aimed at high-end users, such as American campers and hunters. Existing D-cell sized LED flashlights are mostly of the heavy-duty variety, with impact- and water-resistant casing and arrays of super-bright LEDs. These extra features push the prices into the $30 to $60 range – too expensive for our community.

Our alternative to the conventional incandescent type flashlights used in the community is a simple LED retrofit. That is, simply by exchanging the incandescent bulb in the flashlights that they already use with LED bulbs, the efficiency gain can be tremendous, and the first cost reduced. Such flashlight LED bulbs already exist on the market, but their cost is prohibitively high. Such bulbs are sold for $10 to $40, and few are appropriate for use with a 2 D cell type flashlight. Even a $10 cost barrier is too high to be widely affordable.

We concluded that a do-it-ourselves type LED retrofit would be most effective at reducing initial cost, optimizing for long battery lifetimes (by reducing light output) and, most importantly, engaging the community with the project and providing maximum economic benefit. By having the LED retrofits produced on site, they will become a local product and source of much needed employment.

There is great demand for a low cost high efficiency flashlight within the community. When the twelve community members were surveyed in our informal survey, they unanimously responded that they wanted more efficient flashlights. Furthermore, the economics of a low-cost retrofit will surely speak for itself.

We calculated the net present value (NPV) of a 3 dollar investment in a 2 bulb LED retrofit. Assuming that the user depended upon zinc-chloride type batteries, the LED retrofitted flashlight costs 11 cents per hour less than the incandescent to operate. Even including a 50% discount rate, the payback time for the retrofit is so fast that the NPV curve appears nearly linear (Figure 12). The user will break even after only twenty-seven hours of use! Since flashlights are depended upon so heavily, this twenty-seven hour mark should be reached within two weeks. Families should find a $3 fix most acceptable and economical. Within a year, a family that originally bought one pair of batteries/week for their flashlight (a lower limit of typical use) would save about $63. This will be a major economic relief and a positive step in poverty reduction. The actual number could be much higher, depending on battery use.

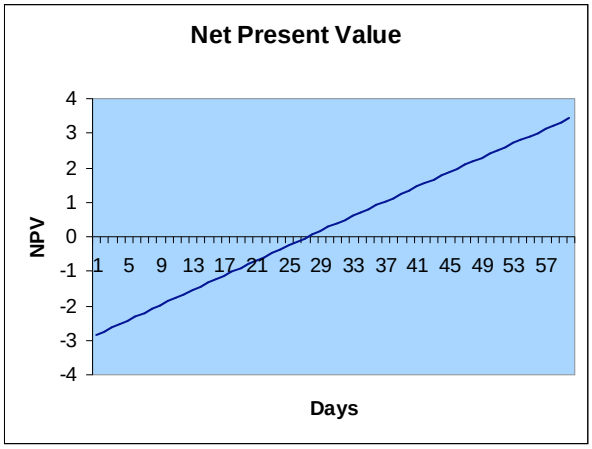

Figure 12: Net present value of a $3 investment into a LED retrofit. Assuming the flashlight is used for 1 hour/day, the breakeven point occurs after 27 days. Assuming a 50% discount rate.

Business Model

These flashlights potentially represent a great economic benefit to the community. We propose to have these retrofits assembled in Soloy, providing reduced product cost and employment for community members. This project will be self-sustaining because people in the Soloy will gain financially from its success. Once people are trained to make the LED retrofits and order the supplies they need, they will be empowered with a new entrepreneurial opportunity. The entrepreneurs that we assist will be provided with limited access to the necessary equipment to manufacture the LED bulbs (which is simply a soldering iron, solder, and LEDs) in a loan agreement. When the entrepreneur's supply is exhausted, we will then replenish his/her supplies from a limited stock that we will initially provide. Eventually, we will encourage the entrepreneurs to order the necessary materials on their own, when they have accumulated sufficient capitol. In this way, we hope the business will be a sustainable one.

Specifically, we will start this endeavor with the supplies to manufacture 250 replacement bulbs. They will be doled out to selected entrepreneurs in batches of twenty-five bulbs at a time. When they sell

enough products to pay back the cost of the LEDs, they will receive the next batch. We will select someone responsible and trustworthy to keep the supplies. This person will also receive a portion of the profit, which would add an estimated $.10 to the price of the product.

We calculated the cost of producing such retrofits based on the price of LEDs (obtained from Nichia), a battery-powered solder iron, and a labor cost of $.25/item. This labor cost is reasonable because anybody who becomes skilled at completing the retrofits can easily build more than four flashlights in an hour. Thus such a person could earn more than $1/hour, the minimum wage in Panama. Since Ngöbe people rarely earn minimum wage, a better comparison would be to what women typically earn for their crafts, which is about $.20/hour.

Because these items have such a high efficiency gain and quick payback period, we anticipate a first cost of $2 to $4 to be acceptable. Thus there is great potential profit for a retrofit-manufacturing entrepreneur. The local women's group has already expressed an interest in being involved in the manufacture and marketing of these items.

Summary of Manufacturing Costs

Startup (one time) costs
Soldering Iron: $30

Continuing costs for producing 2 LED flashlights

Number produced	2 White LEDs (including shipping and customs)	Supply Management	Solder	Electricity	Labor	Cost	Capitol required to produce order (including soldering iron)
100	$2.30	.10	.01	.03	.25	2.69	$289
250	$1.50	.10	.01	.03	.25	1.89	$447
1000	$1.30	.10	.01	.03	.25	1.69	$1180

With an upper limit production cost of $2.69 each, the prototypes could be marketed at $3.50 to $4 and provide a nice margin of profit. With a $1.69 manufacturing cost, they could be marketed at $2.50 to $3. For comparison, the current cost of an incandescent flashlight in Soloy is $1-$2, and a pair of batteries is $1-$1.50.

In order for this business to get established and become a part of the community, startup capitol needs to be provided. Until such time as it becomes self-sustaining, members of the community will need the continued support of UC Berkeley students in areas such as design modifications and dissemination strategies.

Potential Market

Though the population of Soloy is 2,500, the potential market for such a retrofit would extend well beyond the borders of this village. People are continuously moving through Soloy, as it has a health clinic, school and road that other villages lack. Thus the potential market for this project is the region of Besiko, with a population of 16,800. If this project proves successful, then it could be expanded to other regions in the Ngöbe-Bugle Comarca. With a population of 115,000, there is great potential for scaling.

Dissemination Strategies

When we bring our product to Soloy we will begin the dissemination process. We have come up with several strategies for dissemination. We will take advantage of the radio in Soloy to send radio announcements about the flashlight as well as invite people to attend educational workshops. We will identify the "opinion leaders" and invite them to use our flashlights. We are also planning to give educational talks in the school about the benefits of the LED flashlights. In order to encourage attendance of our public workshops, we will offer a free movie screening. This is a popular activity in Soloy which will surely attract a crowd. Additionally, we will work with the local grassroots organization, Medo, to continue the promotion of the product after we leave.

Social and Environmental Impact

This project has potential for significant social and environmental impact on the Soloy community. In a community with a daily income of $1- $2, the saved income per family of $63 per year will be a huge economic relief and step in poverty reduction. This enables families to increase their standard of living. Each retrofit saves each family at least $63/year in battery expenses. If 1000 retrofits were put into use, more than $63,000 goes back into the pockets of people living in poverty. This is a great return on investment. If we were able to scale up our project to other villages and implement similar programs and replace 10,000 incandescent bulbs, the return would be more than $630,000. And if we were finally able to reach the whole Ngobe-Bugle Comarca and replace 50,000 incandescent bulbs, the net savings would be 3.15 million dollars every year.

Additionally, this project will make a significant social impact by empowering the people with an entrepreneurial opportunity. We plan for the retrofits to be assembled by locals in Soloy to reduce product cost and provide employment for community members. Once the community members are trained to make the LED flashlight bulbs and order the necessary supplies, they will also be able to operate their own businesses providing these services. The estimated labor cost is $0.25 per retrofit, which translates to at least $1 per hour. This is the minimum wage in Panama, but above what is typically earned in Soloy. The project will be self-sustaining and everybody in Soloy, from those who open and run the business to those using the retrofits, will gain financially from this technology. Additionally, this venture can boost confidence and in community members, as they will be empowered with the ability to manufacture a valuable product while helping their village.

This project also has an important environmental impact. The result of making more efficient flashlights is a drastic decline in battery usage. With no proper garbage disposal system in Soloy, trash is often buried, burned, or tossed into the river. By reducing the number of batteries used, we simultaneously reduce heavy metal contamination of water sources and reduce the danger and pollutants involved in burning batteries. By increasing battery lifetime by 30 times, if we were able to retrofit every flashlight in the community, we would reduce battery pollution to 3% of its current value. This translates to approximately 3500 batteries/year.

Survey

We began our project with an abundance of ideas for how to decrease the cost of lighting in the Soloy village. To properly focus our project on technologies that the Ngöbe people could accept and adapt to, we needed good survey information. We began with an informal pilot survey to twelve community members. These community members are adults taking an English class, and are Anna's former students. This gave us key starting information for how to direct our designs. The results of the pilot survey were very useful, and showed a unanimous interest in a more efficient flashlight. Additionally, the respondents indicated that they used their flashlights for a myriad of activities such as walking, reading, cooking, and performing other household duties. Another unexpected outcome of the survey was that it revealed a presence of solar panels in the community. Three of the people surveyed had solar panels. However, this initial survey was inherently flawed. As the people surveyed were English students, they tended to be members of the community that had higher than average levels of education and income. Additionally, 12 is not a good sample size to properly ascertain the needs of the community. Therefore, we are administering a formal survey with a wider scope. Our survey has recently been approved by the Center for the Protection of Human Subjects (CPHS) office. See the Appendix V for the forms submitted to CPHS. As of now, the survey is in progress. The method is described below.

Method

When writing our survey questions, our goal was to get an idea of the energy uses in Soloy, to inform this and future Soloy-based energy projects. We first wrote the questions in English and discussed them with our mentors and others. We then revised the survey and translated it into Spanish. We then sent the Spanish version to our local contact, Adan Bejerano Rios, and used his input to create the final version of the survey. The survey consists of about 30 questions on such topics as flashlight use, battery type use, and indoor lighting. See Appendix IV for the survey.

In order to best sample Soloy, we utilized techniques well established in similar rural communities. To assure a high number of quality answers and establish the results, we decided to target 15% of households in Soloy, or 60 families. The residents of Soloy tend to be geographically segregated based on income, so we decided to geographically stratify our results. That is, 15% of each of 19 neighborhoods will be selected to participate in the survey. The neighborhoods were chosen based on the 2000 Panama census; five neighborhoods were excluded due to their having fewer than 10 families; one neighborhood was excluded due to its being too far to practically sample.

The survey is being administered by locals, led by Adan. He recruited, trained and coordinated the local effort. The training consisted of having the administrators practice the random walk method and practice asking each other the survey questions. Additionally, Adan accompanied each of the administrators for at least one interview to ensure their compliance with the surveying method.

Participants in the survey were chosen via our version of the random walk method: the administrators carried into the field with them a pen and a bag with assorted numbers. The administrator then dropped the pen and selected a number out of the bag. They then walked in the direction of the pen for the number of paces indicated by the number. The goal of this process is to reduce the skew in sampling due to such biases as interviewers selecting households based on familiarity. Each survey was completed via an interview, in order to best assure the quality of the answers. As there is a high illiteracy rate in the community, depending upon a written survey would have been impractical. In order to assure voluntary participation, each interviewee was read aloud a consent form and asked to sign it. The survey and

consent form were written in Spanish, as a well accepted written form of the local language, Ngobere, does not exist. The interviewers were instructed to explain the consent form and the survey questions in Ngobere if the survey participant felt more comfortable in that language. We have just received word that the survey has already been administered to forty-eight families. We expect it to be completed in the next few days.

Current and future work

We are excited about the prospect of taking this project to the field. In the end of May, two team members, Kimberly Lau and Anna Zaniewski, will be going to Soloy. Our activities include showing the retrofits to various members of the community to get direct feedback and verify either their usability or need for design modifications, meeting with entrepreneurs and groups such as the women's group who are interested in taking on the construction of the retrofits, giving workshops to those interested parties who want to learn how to build them, giving educational workshops or seminars at the school about the new technology and its advantages, and plotting a sustainable path for the future of our project.

After the Soloy trip this summer, much work remains to be done. We have just begun the work on this project: we have identified the problem and a potential solution. However, going from here to full implementation will take a lot of work and dedication. At this point, we have a group of three dedicated UC Berkeley students, but we recognize that to better implement this project, more student involvement is ideal. If ERG 291, design for sustainable communities, is offered again next year, we will propose this project as one that members of that class work on. We have also talked with the UC Berkeley chapter of Engineers for a Sustainable World about giving this project a home in their organization or in a decal class that they may offer in the fall. Because this project addresses an issue that is not specific to one small village in Panama, there is great potential for expanding this to more and more communities, in many different countries. This is an excellent opportunity for a long term student project.

In trying to secure funding for the future of the project, we applied to the Bears Breaking Boundaries Competition in the Global Poverty Reduction category. Prizes range from $1,000 to $10,000. We also applied for a grant from the National Collegiate Inventors and Innovators Alliance (NCIIA) for the amount of $6,380.

We plan to continue working on this project in the coming Fall semester and beyond.

Possible Future Project: Solar Panel Rejuvenation

A future project that can be considered is capitalizing on a currently untapped, source of light for Soloy – through solar panels. During a preliminary survey of students in Soloy, it was discovered that a past project had donated and installed 80 solar panels in the community. However, there had been no effort to maintain the panels. Additionally, the batteries that plug into the solar panels have expired and are too costly for the Ngöbe people to replace. As such, the solar panels are no longer functional.

Fortunately, the solar panels can be rejuvenated. The current battery type that is compatible with the solar panels can be replaced with a cheaper option so the residents can afford to power lights with the panels again. Additionally, a D-cell battery charger can be developed so residents can recharge the D-cell batteries used for flashlights on the panels.

Though we did not ultimately pursue the solar panel project, the progress that we made on that front consisted of doing some background research into rechargeable batteries, and trying to determine which

would be most appropriate for this application. Most commercially available rechargeable batteries that are available in the standard cylinder sizes of AA, C, D, etc are NiMH or NiCd chemistries. The NiCds tend to have memory problems, and cadmium is a nasty heavy metal to throw away- much worse than the currently used dry cell batteries contain. In the affluent parts of the world, it is generally assumed that NiCds will be recycled, or at the very least, not thrown indiscriminately into the garbage. The last thing that we want to do is introduce a pollutant into the community. This is of particular concern since virtually no waste disposal systems exist in Soloy. The chemistry type NiMH is much better environmentally, but costs more than NiCd. NiMH does not tend to have memory problems. Therefore, if one were to go ahead with a rechargeable battery project in a place like Soloy, we would recommend NiMH type battery chemistry. It should be noted, however, that the tropical climate in Panama would likely reduce the lifetime of rechargeable batteries.

Though lithium batteries are more environmentally benign, they are not widely made in D cell sizes, for safety reasons. If they're put into a regular charger they could literally blow up. In general, rechargeable lithium ion batteries are custom made, and not generally available for generic applications.

These goals were not explored during the course of this semester, but constitute possible focuses for future groups in ERG 291.

New Member Recruits

Jed Duersch is a first year physics student devoted to making the world a more sustainable place. His current research activities include experimental plasma physics, which has applications for clean energy production via fusion. His role in this project is secondary researcher.

Noelle Cole is a graduate student of city planning, who is passionate about sustainability. She is contributing to the marketing and business aspects of this project.

Angela Cheung is a MBA student who is interested in helping us with the business aspect.

Sara Beckman is a UC Berkeley professor and a member of the Haas Operations and Information Technology Management Group. Her research interests include innovation and design management, new product development, operations strategy, and environmental supply chain management. She serves as our financial advisor.

Rejected Designs

In the beginning of the semester, we considered several approaches for reducing battery dependence. These included battery-free flashlights, such as those powered by shaking or cranking. A market survey revealed that such flashlights are available in the $1 to $40 price range, and with widely variable quality. Most of the low-end “shake up” flashlights are not even battery-free but depend on a non-rechargeable lithium coin battery. With a current capacity of 160mA, this flashlight would work for a mere 8 hours before permanently failing! The more expensive shake-up and hand-crank flashlights rely on rechargeable batteries. This is a better design, but not ideal, since even rechargeable batteries only last for months before losing their ability to recharge.

We also considered human powered flashlights that worked by charging capacitors. This was the only option we considered truly sustainable because a capacitor will work for years and years. However, these flashlights tended to be expensive, starting at a $10 cost and rising, and thus out of the budget of our clients. We considered training locals to make their own capacitor-based shake flashlight.

However, we ultimately decided that this approach would be too intensive; a large number of parts would need to be imported into the community, solid technical skills would need to be developed to assemble the flashlights, and most dauntingly, a large effort would be needed to promote the major shift in technology use. People are used to simply turning on a flashlight to use it. It would be a major behavioral shift to introduce shaking or cranking to flashlight use. Additionally, shaking and cranking would be especially cumbersome when carrying large loads or doing manual tasks.

We decided to adopt the 2-LED design over the 3-LED design because the 3-LED bulb flashlight did not show significant improvements in light quality. Additionally, building the retrofit with 3 LEDs reduces battery lifetime and increases first cost.

We also considered adding some circuitry into the design. We considered a so-called "Joule thief circuit" which consists of a one-to-one transformer and a transistor which functionally changes the DC (steady) current of the battery into an alternating current through the bulb. The advantage of this circuit is that it would double the battery lifetime of the flashlight, by basically turning on and off 10,000 per second. Though relatively simple, this circuit is still too cumbersome to build and fit into the bulb sleeve, and would increase the number of parts and labor necessary to assemble it, increasing first cost. The circuit is shown in Figure 13.

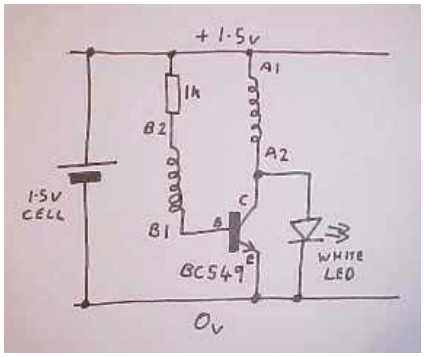

Figure 13:The Joule-Thief Cirucit (from bigclive.com)

Additionally, we looked into a power conditioning circuit from National Semiconductor to regulate the voltage into the LED. However, these integrated circuits require intricate wiring and would increase the complexity of assembling the retrofit, as well as the first cost.

Potential Budget

The ultimate success and scale of this project depends on the funding allocated to it. In order to begin this project, it is absolutely necessary to provide seed money for the business start-up. Because charity is not a sustainable path to poverty reduction, such seed money would be considered a low or no interest loan, which would be granted to a group that showed interest and organization sufficient to produce and market the retrofits. We have already identified one such group in Soloy, Red de Mujeres de Besiko (network of women of Besiko) that are already organized in craft production. The money allocated to this project would ideally be at a scale that would enable the largest possible access to this technology. Once the loan is paid off by the group, the principal could be used to start another group in another village assembling the retrofits. In this way, this project could have far-reaching impact for little investment. However, as this process would be very slow (since the bulbs would not be sold instantaneously and the loans would take a few months or more to be paid back) it would be ideal to have several businesses started simultaneously in more than one village, in order to maximize benefit to the communities involved. We would start the project in Soloy, since its infrastructure makes it the ideal place to begin a campaign, but we would ultimately expand it to more villages.

In addition to the seed money that is required to start these projects, the team of students at Cal will need a budget to ensure its success. Costs include travel to Panama, purchasing of components for new prototypes, and miscellaneous expenses. As this is not a project that could be easily accomplished remotely, several trips to Panama would be required to ensure its success. Additionally, sending 2 students at a time would be needed, as each trip would be very intensive and require 2 team members to run workshops, train in manufacturing, make necessary design modifications, etc.

Budget Breakdown to bring 2,000 LED bulbs to 2 villages

Seed money for LED bulb assembly business	$1500
Trip to Panama to oversee startup (end of summer 2007)	$800*2=$1600
Trip to Panama for follow-up (winter break 2007)	$800*2=$1600
Seed money for second business startup	$1000
Trip to Panama to oversee second business startup (early summer 2008)	$800*2=$1600
Trip to Panama for follow-up (late summer 2008)	$800*2=$1600
Miscellaneous expenses, eg. Purchase of materials for design modifications, etc.	$1100
	Total: $10,000

At this scale, if our project proves successful, it would have a benefit of more than $126,000/year. Thus a $10,000 investment would be well spent.

Conclusion

We have demonstrated that with a simple technological fix, at least $3.15 million a year could be saved by the people in the Ngöbe-Bugle Comarca, translating to $63/year for every flashlight. This is one of the poorest areas in Panama, where people earn $1-$2/day so the savings would be a significant step in poverty reduction. LED bulbs are a viable and affordable alternative to incandescent bulbs, and our method of retrofitting is easily adapted to a resource-scarce environment. By manufacturing the retrofits in the village, people will be empowered with entrepreneurial opportunities. The effects of our project will resonate in social, financial, and environmental aspects of the citizens in Panama and eventually, other developing countries as well.

Acknowledgements

We could not have done this project without the dedicated support of our mentors and sponsors. In particular, Ashok Gadgil, Jonathan Slack, Howdy Goudey were invaluable mentors throughout the semester. We would also like to thank Susan Amrose for being a thoughtful and helpful GSI. Additionally, we are grateful to the Blum Center for sponsoring this course and providing us with the $1,000 grant as well as a $800 travel grant.

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Appendix I: Email from Adan Bejerano Rios (olorobo@hotmail.com) about the flashlights

Hi Anna,

My family told me that they better prefer the new flashlight and they agree also that the battery lifetime is longer. One battery that last two days in the old flash it had like a week in the new flashlight you sent and still work fine. So we think that the new flashlight can hold longer the battery we use here in Soloy like for two or three week. Of course it will depend how often we use it. So this is a good news for us. People are willing to pay until 5 dollars minim for a new brand flashlight where the battery can last for a longer period of time. If we can guarantee these possibilities I think it would be very convenient for all fo us. I can not understand very well line number 4 in the previous email. Please tell me more about it. I will send you some data in the way them. Cerro Venado is the community that federico can not get. We also look forward to seeing you again. We informed to many of the community members that we could hold a meeting where they can ask more question and even we can have them try samples of the flashlight we want to introduce in the district. I think the workshop you have asked for with the women's group and the community and school will be of great help to clarify any question that some people might have. It is also a great idea if we can get to school also for presentation. I really would look forward to it. Thank for the update.

Adan

Appendix II: Neighborhoods surveyed

Name of neighborhood	Number of Families Surveyed	Total number of families living in neighborhood
ALTO DE MANGO	5	27
ALTO DE NARANJO O SERPIENTE	1	13
ALTO EL JAZMIN (P)	0	1
ALTO SOLOY	1	12
BARRERO	3	15
BASO MIEL	1	8
BOCA DE CAÑA	1	13
BOCA DE HACHA (P)	1	6
BOCA DE HUSO (P)	3	20
BOCA DE JEBAY	10	72
BOCA DE SOLOY	9	60
BOCA MIEL	5	27
CABECERA CORRALES (P)	1	8
CABECERA DE BAÑO	0	1
CABECERA DE JUNCO	0	1
CABECERA MIEL	1	12
CERRO MIEL	5	33
CERRO PELAO	0	2
CERRO VENADO *	0	19
CERRO VIEJO (P)	5	31
GASPARILLO	1	8
JEBAY (P)	1	5
QUEBRADA EL NANCE (P)	1	7
QUEBRADA HACHA	0	2
QUEBRADA SUEÑO O ALTO CAÑA	1	13
SALITRE (P)	1	12

*this neighborhood was deemed too far away to sample

Appendix III:

Email from Adan Bejerano Rios (olorobo@hotmail.com) concerning the start of the survey

Hi Anna,

We have been practicing this week and getting also ready to lead the survey from Tuesday the 1st to saturday the 5th of may. *
The following is the name of the people who will be interviewing in the different barriadas.

Urcinia
Yessica
Plinio
Federico

Each of the interviewers are doing five barriadas that they have selected. Here is also a small table summary.

Barriada	**Name**	**Number of**
Alto de Mango	Yessica	5
Alto de Naranjo o Serpiente	Yessica	1
Alto de Soloy	Jessica	1
Boca de Soloy	Jessica	9
Boca Miel	Jessica	5
		21

Barrero	Urcinia	3
Boca de Jebay	Urcinia	10
Boca de Hacha	Urcinia	1
Cabecera Corrales	Urcinia	1
Jevay	Urcinia	1
Cerro Viejo	Urcinia	5
		21

Cabecera Miel	Plinio	1
Quebrada el Nance	Plinio	1
Quebrada Sue o o Alto Ca a	Plinio	1
Bajo Miel	Plinio	1
Boca de ca a	Plinio	1
		5

Cerro Miel	Federico	5
Cerro Venado	Federico	3
Gasparillo	Federico	1
Salitre	Federico	1
Boca de Huso	Federico	3
		13
		60

Tomorrow we all will meet at the development center to discuss final basics before we all fall apart. I will sometime go out with each interviewers to supervise and assist them in the field too.

We will email on monday if we have any questions. The procedures is very easy to follow and so I am sure they all will do well. Let me know if all the above info is ok with you.

My best.
Adan

*The survey did not start until May 4

Appendix IV: Survey

Estudios

Demografía:

¿Cuántas personas viven con usted? _____
¿Cuáles son sus edades? _____
¿Cuántos niños van a la escuela? _____
¿A qué grados asisten? _____
¿Cuántos infantes hay en casa?_____
¿Qué cantidad de tierra tiene usted?_____
¿Dónde las tiene ubicada?_____
¿Cuáles fueron sus fuentes de ingreso el año pasado?
(Marca si o no): artesanía _____ cultivos propios _____ trabajo en tierra de otros _____
construcción_____ Salario _____
Otra fuente de ingreso_____

¿Ustedes usan baterías? Sí _____ No____

¿Cuántas baterías utilizan por semana?_____

¿Para qué usan baterías? Radio ____, Foco_____ Otras _____

¿Qué marca de batería usa? Tiger_____ Panasonic?_____ Otras_____
¿Por qué usa esta marca?
_____ _____ _____

Si compran Tiger:
Si se vendieran baterías Panasonic por $.70 ¿ las compraría usted? Sí ____ No____
por $.60 Sí ____ No____
por $.50 Sí ____ No____

¿Dónde botan ustedes las batería usadas? Hueco en su propia tierra_____ Hueco en su barriada_____
Tira en la basura _____ Tiran en el río_____ Otras _____

¿Cuántos foco tiene usted en casa? _____
¿Para qué usan sus foco? Caminar_____ cocinar_____ leer_____ tejer chacaras_____
Coser____ estudiar Otras_____

Utiliza foco para ir a:

Lugar	Distancia	Frequencia **(Cuántas veces/semana o mes)**	**En que clase de camino utiliza foco sendero o carretera para trasporte?**
Escuela	_____	_____	_____
Finca	_____	_____	_____
Otro Trabajo	_____	_____	_____
Tienda	_____	_____	_____
Fuente de Agua	_____	_____	_____
Familia	_____	_____	_____
	_____	_____	_____
Amigos	_____	_____	_____
	_____	_____	_____
Otra lugar:___	___ _____	_____	_____

¿Cuántos días duran las baterías en sus focos? _____

¿Usaría un foco si fuera menos brillante, pero las baterías duran por mucho más tiempo?
_____

¿Cuánto pagaría por un foco que funcione sin baterías?
B/. 7.00 _____
B/. 6.00 _____
B/. 5.00 _____

¿Qué utiliza para cocinar?
Gas _____ Leña _____ Energía Solar _____

¿A dónde adquiere la leña?_____
¿Cuántas horas cada semana recoge la leña?_____
¿Cuánto paga por semana por la leña?_____
¿Si utiliza una estufa de gas, a dónde lo compra?_____
¿Cuánto le cuesta un taque de gas?_____
¿Cuántos tanque de gas utiliza por mes?_____
¿Dónde esta ubicada su estufa? Dentro _____ afuera_____

¿Cuál es el tamaño de aceite que compra regularmente para cocinar ?
Galón _____
½ galón _____
Botella _____
Pinta _____
bolsita _____

Tiene usted panel solar?____
Si _____ No _____

Funciona? Si _____ No _____

Si no tiene, ¿quisiera adquirir uno?_____

¿Tiene dinero para reparar su panel solar dañado? Sí _____ No _____

¿Cuánto usted podría pagar para reparar su panel solar?

¿Qué tipo de iluminación utiliza en su casa por la noche?
Kerosine__ velas____ fuego___ otro_____

¿Para qué usan la luz? Visita_____ Tareas de casa_____ Tarea de escuela_____
Leer____ hacer artesenía_____ cocinar_____ otra _____

¿Cuántas horas de luz utiliza por noche?_____

¿Cuántas velas compras por semana?_____

¿Qué cantidad de kerosíne cada semana compran?___

Survey: English version

Demographics:

What is the size of your household?
What are the ages of the members of your household?
How many school going children?
What grades do they attend?
How many infants?
How much land do you own?
How far away is your land?
What are your sources of income in the last year? Crafts____ Farming your own land_____
Labor/harvesting on other's land____ construction_____
Other _____

Does your household use batteries?

How many batteries did your household buy last week?
Was this about average?
Estimate how many batteries you usually buy in a week.

What do you use batteries for? Flashlights? ____ Radio?_____ Other_____
What brand of batteries do you use (Tiger or Panasonic)?
Why do you buy that brand?
If you usually buy Tiger batteries, would you buy Panasonic batteries if they cost $.70?
If they cost $.60? If they cost $.50?

How do you dispose of your batteries? Example, do you bury your batteries on your land or throw them in the river or put them in a hole in your neighborhood?
How many flashlights does your family own?
What do you use your flashlight for? Walking____ Cooking ____Reading ____ Weaving Chacaras____
Sewing____ Other_____

What do you use your flashlight to walk to:

Place	Distance	Frequency	Kind of Path (footpath or car road)
School	_____	_____	_____
Farm	_____	_____	_____
Other Work	_____	_____	_____
Store	_____	_____	_____
Getting water	_____	_____	_____
Visiting	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
Other: _____	_____	_____	_____

How many days does your flashlight last with a pair of batteries? (note if they make a distinction between brands)

Would you use a flashlight if it were less bright as your current flashlight but the batteries lasted much longer?

Would you pay $7 for a flashlight that did not require batteries? If no, would you pay $6? If no, would you pay $5? If no, how much would you pay?

What do you use to cook? Example, fire or gas stove.
If you use firewood, where do you buy or collect the firewood?
    How many hours per week do you spend collecting wood?
    How much money do you spend per week buying wood?
If you use a gas stove, where do you buy the fuel?
    How much money per month do you spend buying the fuel?

What size of cooking oil was the last size you bought? (the exact size of the bottle or bag of oil)

Do you have a solar panel installed in your house?
If yes:
    Is it working?
    If not, do you want to have a working solar panel?
    How much money would you be willing to spend to fix the solar panel?

What kind of lighting do you use at night inside your home (candle, kerosene, cooking fire, or other)?
What do you use the lighting for? Visiting_____ Homework_____ Reading_____ Sewing____ making crafts _____ cooking _____ other _____
How many nights per week do you use a form of lighting?
How many candles/week do you buy?
How much kerosene/week do you buy?

Consent Form

I will be asking you questions as part of a study by Anna Zaniewski and Kim Lau, from the University of California, Berkeley. The purpose of these questions is to acquire information about the use of batteries and other sources of energy in Soloy. The information will be used to improve lighting sources for the people of Besiko. The results of the survey may be published, but no identifying information about you will be published.
It will take about 20 minutes.
Participation in this survey is completely voluntary, and that there are no consequences for not participating. The information we collect will be kept confidential.
I _____ understand these conditions and agree to participate in this study.
Signature:_____

Voy a preguntarle algunas preguntas para un estudio de Anna Zaniewski y Kim Lau de la Universidad de California, Berkeley. El propósito de estas preguntas es recoger informacíon acerca usados de baterias y otras fuentes de energía en Soloy. La informacíon sería usado para mejorar fuentes de luz para la gente de Besiko. Las resultas puede ser publicado, pero no informacíon que puede identificar usted sería publicado.
Tomará acerca 20 minutos.
Participacion en este estudio es completamente voluntario y no hay consequencias para no participar. La informacion que recogemos sera mantenida confidencial.

Yo _____ entiendo estas condiciones y acuerdo participar en este estudio.

Firma: _____

Appendix V: Forms to CPHS

CPHS APPLICATION COVER SHEET

Instructions: ***This form must be used with all submissions. Please type,*** *using a different font than the one in this form. Be sure to check off appropriate box(es) for Application Type below.* ***Signatures must be original and legible.*** *Submit applications to the OPHS (see address above). Incomplete applications will substantially delay the review process and may be returned for completion.*

Part I: PROJECT INFORMATION

Protocol Title: Energy Use and Solar Power in a Ngobe Village **CPHS #:**

Lead Investigator: Anna Zaniewski **E-mail:** azaniewski@berkeley.edu

UCB Status: Undergrad ☐ / Grad ☐ / Faculty ☐ / Postdoc ☐ / Visiting Professor ☐ / Other ☐

Department: Physics Campus Mail Code #:

Mailing Address (home or campus): 1601 Allston Way, Berkeley, CA 94703

Phone : (510)684-9487 Fax : ( ) Student ID #: 18406244

Faculty Advisor: Ashok Gadgil E-mail: AJGadgil@lbl.gov

Administrative Contact:

Phone: ( ) E-mail:

Application Type: New ☐ Renewal ☐ Amendment ☐ Core/Training Grant ☐ Exempt Request ☐

Memorandum of Understanding (MOU) involved ☐ Notice of Intent to Rely form attached ☐

UC System MOU ☐ UCSF/UC Davis/UCB MOU ☐ Other MOU ☐

Part II: KEY PERSONNEL (in addition to Lead Investigator)

Name	Kimberly Lau	Adan Bejerano Rios		
UCB Status (student, faculty, etc.)	Grad Student	N/A		
Role (co-investigator, faculty advisor, etc.)	Co-Investigator	Local Coordinator		
Department	Mechanical Engineering			
Campus Mail Code				
Address	2728 Haste St, Berkeley, CA 94709			
E-mail	lauk@berkeley.edu			
Phone	415-994-3688			
Fax				
Student ID	16235343			

Attach additional page if more space is needed.

Part III: FUNDING (including gifts) ***[MUST BE COMPLETED]***

1. Is project self-funded by Lead Investigator? No ☐ / Yes ☐

2a. Has funding for this research been awarded or applied for? No ☐ / Yes ☐ If yes, complete the following for funding received through the UCB Sponsored Projects Office (SPO). If funding not received through SPO, complete #4 below:

Funding Agency/ Source	Title of Grant/Proposal (if different from CPHS title)	Funding Agency/ Source Address	SPO Proposal # (e.g., 20021234)
The Blum Center	ERG291 Course Grant	Haas School of Business	

2b. Will funding for this research be sought in the future? No ☐ / Yes ☐ If yes, submit an amendment to add the funding source to this protocol when it has been awarded.

3a. Is name of Principal Investigator (PI) on grant different from Lead Investigator above? No ☐ / Yes ☐ If yes:

3b. As the PI of this grant, I attest that the Lead Investigator named above has my permission to conduct human subjects research under the auspices of my grant.

Grant Principal Investigator Name (type or print): _____

Grant Principal Investigator Signature: _____ Date: _____

4. If funding is not received through the SPO of UCB or LBNL (Lawrence Berkeley National Laboratory), please explain and provide name and phone number/e-mail of contact person at funding agency.

Part IV: COLLABORATING INSTITUTIONS

1. Are any institutions collaborating in this research? No ☐ / Yes ☐ **If yes:**

Institution Name	Individual Contact/ Affiliate of Institution	FWA #	Local IRB Review?(Y or N)	IRB Approval Date	IRB Approval Expiration Date

2. **Attach a copy of the most recent IRB or Ethics Committee approval.**

Part V: SPECIAL CONSIDERATIONS *[MUST BE COMPLETED]*

Check either "Yes" or "No" and provide information where requested.

1. Do you intend to use ionizing radioactive materials or ionizing radiation-producing devices in your research? (e.g., injectable, oral, x-rays, etc.) No ☐ / Yes ☐ If yes, **Radiation Use Authorization (RUA) #(s):**

2. Do you intend to use any non-ionizing radiation sources (laser or magnetic sources) in your research?

   No ☐ / Yes ☐ If yes, **Laser Use Registration #(s):**_____ and/or **Magnetic Inventory #(s):**

   _____

3. Do you intend to use human blood, body fluids, tissues, or cells (including cell lines)* in the course of your research, by drawing samples, accepting samples already drawn, receiving samples from any source, or in any other way? No ☐ / Yes ☐ If yes, Lab Location: _____ **Biological Use Authorization (BUA) #(s):**

   *NOTE: *If research involves human stem cells (adult or embryonic), see UC Berkeley policy issued 2/15/07*.

4. Do you intend to use any substance or device for which approval from or notification to the Federal Food and Drug Administration (FDA) is required? No ☐ / Yes ☐ If yes, IND # or IDE #:

5. Does this research constitute a clinical trial? No ☐ / Yes ☐ If yes, you must have a clinical trial agreement negotiated through the UCB Industry Alliances Office. **Submit copy of agreement with CPHS application.**

6. Will proprietary drug or device testing be done? No ☐ / Yes ☐ If yes, explain in protocol.

7. Will any vulnerable subject populations (e.g., children, prisoners, pregnant women, fetuses, neonates, cognitively impaired persons, economically or educationally disadvantaged persons) be involved?

   No ☐ / Yes ☐

8.Will surrogate consent be sought? No ☐ / Yes ☐

9.Will research take place outside of the U.S.? No ☐ / Yes ☐ If yes, where: Panama

10. Are you creating, accessing, using, or disclosing Protected Health Information (PHI) as defined by the Health Insurance Portability and Accountability Act (HIPAA) regulations? No ☐ / Yes ☐

Part VI: HUMAN SUBJECTS EDUCATION AND TRAINING CERTIFICATION

Lead Investigator and Key Personnel (*CITI training required if UCB student*)	Type of Training (insert date completed)				
	CITI (Collaborative IRB Training Initiative)	General HIPAA	HIPAA Security	Other Online Training (title & date completed)	Other "Face-to-Face" Training (talk title & date)
Anna Zaniewski	Completed 3/9/2007				

Part VII: FINANCIAL CONFLICT OF INTEREST

Investigators must declare any potential conflict of interest by completing and submitting the **CPHS Checklist for Financial Conflict of Interest: Human Subject Studies.** (See form for instructions.) ☐ Attached

Part VIII: INVESTIGATOR ASSURANCE

- I certify that the information provided in this application is complete and correct.
- I acknowledge my responsibility for the conduct of this study and the protection of the rights and welfare of the human subjects directly or indirectly involved in this project.
- If any changes to this study are needed (e.g., risks to subjects increase; financial conflict of interest arises; any modification of the protocol or attached materials is considered), I will obtain review and approval or determination of exemption from the CPHS ***before*** going forward with changes to the study.
- I will notify CPHS of any serious adverse or unanticipated events and report them according to CPHS policy.

Lead Investigator Signature: _____ Date: _____

Faculty Advisor Signature: _____ Date: _____

Submit <u>complete</u> application materials with original, legible signatures to avoid delay of CPHS review!

CHECKLIST FOR COMPLETE APPLICATIONS
Please check off all items included with your submission:

☐ CPHS Application Cover Sheet (*required with **all** submissions*)

☐ CPHS Checklist for Financial Conflict of Interest: Human Subject Studies

☐ Study Protocol (see CPHS Protocol Narrative Form)

☐ Request for Determination of Exempt Status

☐ Study Renewal/Continuation Form

☐ Study Amendment Form

☐ Core Grant/Training Program Form

☐ Informed Consent Document(s) (unless study is closed to enrollment or waiver of consent is requested)

☐ Assent Document(s) (usually required for minors and some adult subjects not competent to consent)

☐ Medical Research Subject's Bill of Rights

☐ Data Collection Instruments (e.g., surveys, interview guides)

☐ Letter of Permission and/or IRB Approval from Off-Site Institution or Collaborating Institution

☐ Documentation of FDA Approval for Investigational New Drug (IND)/ Investigational Device Exemption (IDE)

☐ Advertisements/Recruitment Materials (e.g., letters, flyers, scripts for verbal recruitment)

☐ Notice of Intent to Rely on Another UC IRB for Review (for applications submitted under UC MOU)

☐ Other documents included:

_____

_____

_____

_____

NUMBER OF APPLICATION COPIES TO SUBMIT

- **New study (non-exempt): 3 sets** (1 original, 2 copies) of CPHS Cover Sheet, Checklist for Financial Conflict of Interest, protocol narrative, consent documents, and other materials as appropriate (see "Checklist for Complete Application" above).

- **All other application types**: **2 sets** (1 original, 1 copy) of CPHS Cover Sheet, appropriate form (e.g., Study Renewal, Amendment, Request for Exempt Status) and other materials as indicated on the relevant form.

REQUEST FOR DETERMINATION OF EXEMPT STATUS

Instructions: This form should be used by researchers who propose to conduct human subjects research which they believe qualifies as **exempt according to federal regulations (45 CFR 46.101[b])**. The determination must be made by UCB's Committee for Protection of Human Subjects (CPHS). **NOTE:** ***No research activities may begin until the research has been reviewed and determined exempt by the CPHS and notification received.***

To apply for exempt status, complete this form and submit 2 copies with the following attachments:

- **CPHS APPLICATION COVER SHEET FORM, with required signature(s)**
- **CHECKLIST FOR HUMAN SUBJECTS FINANCIAL CONFLICT OF INTEREST, with required signature(s)**
- **PROTOCOL MATERIALS and CONSENT MATERIALS** (see instructions in Part II and Part III below)

Lead Investigator Anna Zaniewski **E-mail:** azaniewski@berkeley.edu

Faculty Advisor Ashok Gadgil **E-mail:** AJGadgil@lbl.gov

Protocol Title Energy Use and Solar Power in a Ngobe Village

▪ **CITE EXEMPTION CATEGORY (Check all applicable categories and sub-parts below)**

NOTE: The exemption categories listed below do not apply to research involving prisoners, nor to most types of research with children, subjects vulnerable to coercion, or persons considered to be legally incompetent. All procedures for all subjects in a project must qualify for exemption in order for the project to be deemed exempt by CPHS.

☐ **1. Educational Practices**: Research conducted in established or commonly accepted educational settings, involving normal educational practices such as:

☐ (a) research on regular and special education instructional strategies; **or**

☐ (b) research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

This exemption does not apply to the use of school records of identifiable students or interviewing instructors about specific students.

☐ **2. Educational Tests (Cognitive, Diagnostic, Aptitude, Achievement), Survey Procedures, Interview Procedures, or Observation of Public Behavior**: Research involving these procedures is exempt, **if:**

☐ (a) the information obtained is recorded in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects; **or**

☐ (b) any disclosure of the subject's responses outside of the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing, employability, or reputation

This exemption does not apply to children except for research involving observation of public behavior when the investigator does not interact with the children. Workplace meetings and activities, as well as classroom activities, are not considered "public behavior."

☐ **3. Educational Tests, Survey Procedures, Interview Procedures, or Observation of Public Behavior**: **Research NOT exempt under Category 2**: Research involving these procedures is exempt, **only if:**

☐ (a) the subjects are elected or appointed public officials or candidates for public office; **or**

☐ (b) federal statute(s) require(s) without exception that confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

In most cases, managers and staff in public agencies are not considered "public officials."

☐ **4. Existing Data**: Research involving collection or study of existing data, documents, records, or specimens, **if:**

☐ (a) these sources are publicly available; **or**

☐ (b) the information is recorded by the researcher in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

☐ **5. Research and Demonstration Projects Conducted by or Subject to the Approval of Department or Agency Heads**: This research is exempt **<u>if</u>** it is designed to study, evaluate, or otherwise examine:

- ☐ (a) public benefit or service programs; **or**
- ☐ (b) procedures for obtaining benefits or services under those programs; **or**
- ☐ (c) possible changes in methods or alternatives to those programs or procedures; **or**
- ☐ (d) possible changes in methods or levels of payment for benefits or services under those programs.

☐ **6. Taste and Food Quality Evaluation and Consumer Acceptance Studies:** This research is exempt, **<u>if:</u>**

- ☐ (a) wholesome foods without additives are consumed; **or**
- ☐ (b) a food is consumed that contains a food ingredient at or below the level and for a use found to be safe by the Food and Drug Administration (FDA) or approved by the Environmental Protection Agency (EPA) or the Food Safety and Inspection Service (FSIS) of the US Department of Agriculture (USDA); **or**
- ☐ (c) a food is consumed that contains an agricultural chemical or environmental contaminant at or below the level found to be safe by the FDA or approved by the EPA or the FSIS of the USDA.

▪ **Complete this section if you have cited above Category #4, <u>EXISTING DATA</u>:**

1. Briefly describe your proposed research, including the data/specimens involved, their source(s), and data security/storage measures. (Use the space provided directly below or attach page if needed.)

2. These materials are (*check all that apply*):

- ☐ (a) coded private information or specimens, and the investigator will not have access to the key.
- ☐ (b) from publicly available sources.
- ☐ (c) recorded by the investigator in such a manner that subjects cannot be identified OR any link to identifying information has been destroyed.

3. If applicable:

- ☐ (a) Provide the date (approximate month/year) that original data/specimen collection was completed.
- ☐ (b) If using another researcher's data/specimens, attach copies of the IRB approval (with PI name and study title) plus approved consent form(s) for the original study *IF AVAILABLE.*

▪ **Complete this section if you have cited any of the following categories: #1, #2, #3, #5, #6**

1. **PREPARE AND ATTACH: Two (2) copies** of the protocol and consent materials for CPHS review.
NOTE: *You may adapt the CPHS Protocol Narrative Form or provide your own format, but in either case, the protocol must include information on*:

- Subjects
- Recruitment – Not required for research involving public observations only
- Data collection procedures – Required for all subject groups
- Risks and Benefits
- Informed Consent process – Include consent materials for all subject groups
- Confidentiality measures – See CPHS Data Security Policy

▪ **DO YOU PLAN TO:**

☐ Audiotape? ☐ Videotape? ☐ Take photographs?

If you checked any box under #2 (directly above), be sure that your protocol and consent materials address related procedures, future use of tapes and/or photographs, and special confidentiality issues including data storage methods.

CPHS Checklist for Financial Conflict of Interest
Human Subject Studies

Individuals who have independent roles in projects and who are responsible for the design, analysis, conduct, or reporting of the results of research performed (or to be performed) under a human subjects protocol must disclose whether or not they have a financial interest in or association with the sponsor or the company supplying the materials, drugs, or devices for the project.

This Checklist for Financial Conflict of Interest pertains to the entire project team working under the protocol. If any individual has a conflict, then that individual must comply with university requirements for Disclosure of Financial Conflict of Interest (http://researchcoi.berkeley.edu). Each individual with a positive response to questions 1, 2, or 3 below is also required to submit a Human Subjects Financial Conflict of Interest Form (http://cphs.berkeley.edu/content/forms.htm) with this Checklist.

CPHS staff will forward the materials to the Conflict of Interest Committee for separate review. The COI Committee will contact or notify you directly on all matters related to COI review. CHPS approval or exemption of protocols will be contingent upon the disclosure and resolution of all financial conflicts of interest, as determined by the COI Committee.

This Checklist is to be completed and signed by the project Principal Investigator or by the faculty mentor for a student.
This Checklist and other related forms must be included with all protocol applications to CPHS for new and continuing research.

Project Title: Energy Use and Solar Power in a Ngobe Village

Principal Investigator Name: Anna Zaniewski

CPHS # (if known/assigned): _____

Will anyone who will be recruiting or enrolling human subjects for this research receive a payment for each subject enrolled into this protocol?

☐ Yes
If yes, please identify the individual(s) and explain:

_____

_____

If yes, how much: per subject: $ _____ total: $ _____

☒ No

For UC Berkeley Collaborators in this Study

1. Does the lead researcher, the faculty PI or mentor, or any member of the UC Berkeley project team hold a position (such as board member, scientific advisor, director, officer, partner, trustee, employee or consultant):

   a) With the non-UC entity financing the research?
   ☐ Yes, if yes the individual(s) must fill out a Human Subjects Financial Conflict of Interest Form
   ☒ No

   b) With the non-UC entity supplying the materials, drug, or devices being tested by the project?
   ☐ Yes, if yes the individual(s) must fill out a Human Subjects Financial Conflict of Interest Form
   ☒ No

2. Does the lead researcher, the faculty PI or mentor, or any member of the UC Berkeley project team have an equity interest (stock, stock options, real estate, investment, or other ownership):

   a) In the non-UC entity financing the research?
   ☐ Yes, if yes the individual(s) must fill out a Human Subjects Financial Conflict of Interest Form
   ☒ No

   b) In the non-UC entity supplying the materials, drug, or devices being tested by the project?
   ☐ Yes, if yes the individual(s) must fill out a Human Subjects Financial Conflict of Interest Form
   ☒ No

3. Does the lead researcher, the faculty PI or mentor, or any member of the UC Berkeley project team have equity rights to a pending application or issued patent to an invention(s), license rights, or copyright for software that has a direct relationship to the project?

   ☐ Yes, if yes that individual must fill out a Human Subjects Financial Conflict of Interest Form
   ☒ No

About Non-UCB Collaborators in this Study:

1. Do any collaborators hold a position (such as board member, scientific advisor, director, officer, partner, trustee, employee, or consultant):

   a) With the non-UC entity financing the research?

   ☐ Yes, if yes please identify the individual(s) and explain below:

   _____

   _____

   ☒ No

   b) With the company supplying the materials, drug or devices being tested by the project?

   ☐ Yes, if yes please identify the individual(s) and explain below:

   _____

   _____

   ☒ No

2. Do any collaborators have an equity interest (stock, stock options, real estate, investment, or other ownership):

   a) In the non-UC entity financing the research?

   ☐ Yes, if yes please identify the individual(s) and explain below:

   _____

   _____

   ☒ No

   b) In the non-UC entity supplying the materials, drug or devices being tested by the project?

   ☐ Yes, if yes please identify the individual(s) and explain below:

   _____

   _____

   ☒ No

3. Do any collaborators have equity rights to a pending application or issued patent to an invention(s), license rights, or copyright for software that has an direct relationship to the project?

   ☐ Yes, if yes please identify the individual(s) and explain below:

   _____

   _____

   ☒ No

I certify that the information provided is accurate and complete. I have discussed the requirement to disclose financial conflicts of interest with all members of the project team. The appropriate actions have been taken.

_____

Principal Investigator Signature

_____ _____

PI Name Date signed

⇨ **OR**

Faculty Mentor Signature	Student Name
Faculty Mentor Name	Date signed

CPHS PROTOCOL NARRATIVE FORM

Instructions: ***Complete all applicable sections of this form****. (If requesting Exempt Status, see instructions on Exempt Request form).* ***Please type,*** *using a different font than the one in this form****. Handwritten or incomplete forms will be returned.*** *Use language that is clear, concise, and non-technical wherever possible, and define all acronyms.* ***For renewals or amendments, highlight all changes from the previously approved version on one copy.*** *A grant proposal or thesis will not be accepted in place of a protocol written according to this format.*

Lead Investigator: Anna Zaniewski

Protocol Title: Energy Use and Solar Power in a Ngobe Village **CPHS #:**

Related CPHS Project(s)? Title: CPHS #:

Title: CPHS #:

SECTION 1: PURPOSE AND BACKGROUND OF STUDY

- **Purpose:** Provide a brief explanation of the proposed research, including specific *study hypothesis, objectives, and rationale*.

The purpose of this class project is to reduce battery dependence and enhance access to other sources of power in the Ngobe village of Soloy, Panama. This survey will provide essential information regarding current energy use so we can develop efficient and appropriate technologies for better standards of living.

- **Background:** Give relevant background (e.g., summarize previous/current related studies) on condition, procedure, product, etc. under investigation, including citations (with attached bibliography) if applicable.

In the marginalized indigenous village of Soloy, Panama, the members of the community have a very limited access to energy resources. Because there is no electricity, lighting is a huge economic drain. Candles and kerosene are used indoors at night, both of which are very expensive as they have to be replenished daily. Additionally, the population is dispersed and people walk long distances, often in the dark, so many rely upon flashlights which consume a large amount of batteries. The batteries, candles, and kerosene represent a major portion of families' disposable income. Furthermore, a lack of proper disposal facilities means the batteries create an environmental problem.

In order to address these problems, it is our goal to empower the citizens of Soloy to have greater access to clean, affordable energy. The specific ways in which we will address the problem include introducing flashlights with efficiencies several times the current efficiency of the incandescent flashlights that are being used. We will also investigate how to revitalize solar panels that were given to the community a few years ago but have since fallen into disrepair.

In order to best address the needs of the community, we must have data about energy use. The survey is essential for moving forward with our goals. The survey will be conducted via interviews of locals by locals, in order to ensure as smooth of communication as possible. The participants will be selected via the random walk method, and will be stratified according to geographic location. We have census data for the different neighborhoods, and will target 15% of households. There are about 400 families in the community, so we are targeting 60 families.

- *International research*: If research will be done outside the U.S., see CPHS Guidelines on Conducting Research Abroad—Demonstrating Knowledge of "Local Research Context."

Our principal investigator has spent a year living in Soloy and is familiar with cultural norms and sensitivities of the community. Additionally, the survey will be conducted by a group of locals, who we are continuously collaborating with to achieve the most culturally sensitive and effective survey and product design. Both investigators are

conversationally fluent in Spanish, and the lead investigator has been acquainted with the native language of Ngobere. Based on conversations with community members, we sense great enthusiasm about this work.

The survey will target random families who will be informed of the voluntary status of this survey and the right to participate or not participate without consequence. In order to bridge potential literacy barriers, this survey will be conducted orally in the language the respondents are most comfortable with, Spanish or Ngobere.

- *Collaborative research*: If any non-UCB institutions or individuals are collaborating in the research, discuss here and complete CPHS Cover Sheet, Part IV, *attaching any relevant IRB approvals*.

We will be collaborating with Soloy locals, who will be conducting the survey. They will be paid for the efforts.

SECTION 2: QUALIFICATIONS OF STUDY PERSONNEL

- **Expertise:** Explain expertise of Lead Investigator, Faculty Advisor (if applicable), any co-investigators or other key personnel listed in the application, and how it relates to their specific roles on the study team.

The lead investigator is Anna Zaniewski, a PhD student in Physics. For specific qualifications, see above note. The co-investigator is Kimberly Lau, a graduate student in Mechanical Engineering. The faculty advisor, Dr. Ashok Gadgil, has been extensively involved in disseminating appropriate technologies to impoverished communities.

- **Training:** For *graduate or undergraduate students* who are Lead Investigator or key personnel of the study, confirm training to conduct research with human subjects (required for all student researchers—see CPHS Cover Sheet, Part VI). *Attach copy of completion report for each individual, unless submitted previously*.

SECTION 3: SUBJECTS (Persons/Records/Specimens)

- **Eligibility:** Describe proposed subject population, including criteria for study inclusion and exclusion (e.g., age, health status, language). If any inclusion/exclusion criteria are based on gender, race, or ethnicity, explain rationale for the restrictions. Indicate how, when, and by whom prospective subjects will be identified and eligibility determined (provide fuller discussion of recruitment, screening, and consent process in Sections 4-6). Describe randomization or other assignment method for intervention and control groups.

The population of Soloy is 2600 residents in 428 families, geographically distributed in 25 neighborhoods, according to the 2000 Panama census. Neighborhoods are often segregated by socio-economic status, so in order to properly stratify the results, we have decided to sample families in each neighborhood. The interviewers will be instructed to select subjects randomly, via the random walk method often used in rural locations. The interviewers will go to each neighborhood, and following a randomizing method, choose a direction and distance to walk, to then select the family that most closely intersects their path.

The interviewer will ask to speak with the head of household of each family selected. If the head of household is not available, the interviewer will ask to speak with another adult. The subject will be notified that the survey is completely voluntary and without consequences for participating or not participating.

- **Number:** State total number of subjects planned for the study and how many must be recruited to obtain sample size. Explain how number of subjects needed to answer the research question was determined.

We plan to survey 15% of families in Soloy, which comes to about 60 families. We are expecting that not all surveys will be completed in their entirety, so we should have at least 40 complete surveys. We came to this number after consulting with people who are familiar with conducting surveys in rural settings.

- **Vulnerable Subject Groups:** Indicate whether any proposed subjects are children/minors, prisoners, pregnant women, those with physical or cognitive impairments, or others who are considered vulnerable to coercion or undue influence.

N/A

SECTION 4: RECRUITMENT

- **Summary:** Explain how, where, when, and by whom prospective subjects will be identified/selected and approached for study participation. NOTE: If researcher is subject's instructor, physician, or job supervisor, or if vulnerable subject groups will be recruited, explain what precautions will be taken to minimize potential coercion or undue influence to participate.

In summary, we are conducting research in the Panamanian village of Soloy, as soon as we attain exempt status. Subjects will be randomly selected and stratified according to geographic location. They will be approached in their homes by the interviewers who are our local collaborators native to the area.

- **Recruitment Materials:** Describe and *attach samples of any recruitment materials* (e.g., letters, flyers, advertisements [note type of media/where posted], scripts for verbal recruitment, etc.).

N/A

- **Permissions:** If applicable, describe and *attach IRB approval or letter of permission/ cooperation* from institutions, agencies or organizations where off-site subject recruitment will take place (e.g., another UC campus, clinic, school district).

N/A

SECTION 5: SCREENING PROCEDURES

- **Summary:** If prospective subjects will be screened via tests, interviews, etc., prior to entry into the "main" study, explain how, where, when, and by whom screening will be done. NOTE: *Consent must be obtained for screening procedures as well as "main" study procedures. As appropriate, either: 1) create a separate "Screening Consent Form;" or 2) include screening information within the consent form for the main study* (see Section 6).

N/A

- **Identifiable Personal Information:** Indicate if identifiable personal information will be obtained as part of the screening process. (Confidentiality issues should be addressed in Section 11).

Names will not be collected as part of the survey, but we will ask demographic information such as number of children, etc.

SECTION 6: INFORMED CONSENT

NOTE: See CPHS Informed Consent Guidelines before completing this section.

- **Summary:** Explain how, where, when, and by whom informed consent and/or assent will be obtained. NOTE: If any vulnerable subject groups/other special circumstances are involved (e.g., use of surrogate consent), address considerations appropriately.

Interviewers will explain to subjects that the survey is completely voluntary and there are no repercussions for participating or not participating. They can choose skip any question that they are not comfortable with.

- **Consent Materials:** Describe any consent/assent form(s) to be used, and *attach copies.*

  If *screening procedures* will be done for the study, see above. Whichever method is used (separate consent or part of the main consent), the form should include a statement regarding what will happen to screening information collected for individuals who do not enter the study.

  If any *vulnerable subject groups* will be involved, address appropriately (e.g., if study includes minors, both an assent form for the child and a consent/permission form for the parent(s) may be required).

  For *international research*, provide for and describe *local contacts* in the area.

The consent form will be read orally in Spanish and translated into Ngobere if the participant is more comfortable in that language. The participant will then be asked to give their verbal consent and sign the form. In the case that the person is illiterate they will be asked to mark the page to represent a signature.

The local contacts include Adan Bejerano Rios, who Anna Zaniewski, the lead investigator, worked closely with while in Panama. He will recruit other locals who are literate and feel comfortable in Spanish and Ngobere to conduct the interviews. Mr. Rios is highly educated, and leads a small grassroots organization aimed at sustainable development.

- **Request for Waiver of Consent:** If you are requesting waiver of any of the required elements of informed consent, or waiver of documented consent, or waiver of parental consent or child's assent, provide justification and describe plans for any additional safeguards. (See CPHS Informed Consent Guidelines).

N/A

SECTION 7: STUDY PROCEDURES

- **Summary:** Describe how the research will be conducted, providing information about all study procedures (e.g., interventions/interactions with subjects, randomization, photographing, audio- and/or videotaping, data collection), including follow-up procedures. (Screening procedures should be discussed in Section 5). Be sure to make clear what the sequence of study procedures is (i.e., describe in chronological order).

The research will consist of interviewers asking questions to participants orally and recording their answers. There will be no other procedures used during the survey.

- **Study Personnel, Location, Time:** Explain who will conduct the procedures, where and when they will take place. Indicate frequency and duration of visits/sessions, as well as total time commitment for the study.

The study will be conducted by locals in the Soloy village. The interviewers will receive training to prepare them for administering the surveys. We anticipate the interviews to last fifteen minutes each over the course of seven days.

- **Experimental vs. Standard Procedures:** Identify any procedures that are experimental/ investigational and explain how they differ from standard procedures (medical, psychological, educational). If applicable, distinguish between procedures that the subject would undergo regardless of enrollment in the study and procedures done specifically for study purposes.

N/A

- **Deception:** This includes both *"active deception"* (deliberately giving false information about study purpose and/or procedures to subjects) and *"lack of full disclosure"* (withholding complete information about the study from subjects.) If any type of deception will be used, explain what it will entail, why it is justified, and what the plans are to debrief subjects. Also, attach debriefing forms(s)/materials. (NOTE: If study involves significant deception at time of subject enrollment/consent, the CPHS may require a post-study re-consent as part of debriefing process).

N/A

- **Drugs/Devices:** If study involves an experimental drug or device, complete IND/IDE information on CPHS Cover Sheet. Describe any study drug here, including generic and/or chemical name, how it is supplied (e.g., powder, capsule, liquid), administration method and schedule, etc.

N/A

- **Placebo:** If placebo will be used, provide rationale and explain why active control is not appropriate.

N/A

- **Data Collection Instruments:** If interviews, questionnaires, surveys, or focus groups will be conducted for the study, provide citations for standard instruments and *attach 1 copy of any non-standard instruments to be used*.

The following instruments will be used:

– Paper
– Pen

- **Identifiable Personal Information:** Indicate if identifiable personal information will be obtained from/about subjects. (Confidentiality issues should be addressed in Section 11).

Names will not be collected as part of the survey, but we will collect demographic information such as number of children, etc.

SECTION 8: RISKS/DISCOMFORTS

- **Summary:** Describe all known risks, discomforts, and/or side effects of study procedures, whether physical, psychological, or social (e.g., pain, stress, invasion of privacy), noting probability and magnitude of potential harm. Include risks of randomization and placebo if applicable.

N/A

- **Measures to Minimize Risks/Discomforts:** Discuss measures that will be taken to minimize risks or discomforts to subjects.

N/A

- **Currently Unknown Risks:** If applicable, indicate if a particular study treatment or procedure may involve risks to the subject (or to the embryo or fetus, if the subject is or may become pregnant) that are currently unforeseeable.

N/A

SECTION 9: BENEFITS

- **Summary:** Describe any potential benefits to the individual subject, group of subjects, and/or society. If subjects will not benefit directly from study procedures, this should be stated. NOTE: Do not include compensation/ payment of subjects in this section, as remuneration is not considered a "benefit" of participation in research (compensation/ payment should be addressed in Section 12).

The participants will not benefit directly from this survey. However, the information collected will be used to guide us in optimizing our products to their specific user needs. For example, we hope to reduce battery dependence to 10% of the current usage, as this could potentially save families 10% of their disposable income per week.

SECTION 10: ALTERNATIVES TO PARTICIPATION

- **Summary:** Describe appropriate alternative resources, procedures, courses of treatment, if any, that are available to prospective subjects. If there are no appropriate alternatives to study participation, this should be stated. If the study does not involve treatment/intervention, put "N/A" here.

N/A

SECTION 11: CONFIDENTIALITY

NOTE: See CPHS Data Security Policy before completing this section.

- **Summary:** Explain how subject privacy will be protected and how confidentiality of subject information will be maintained.

Sensitive data will not be collected in this survey.

- **Access to/Security of Study Records:** Discuss who will have access to study records/specimens and how the records will be secured. Address all applicable points below:

1. Will subjects be asked to give permission for release of identifiable data (e.g., information, videotapes), now or in future? If so, explain here and include appropriate statements in consent materials.

   At the time that participants are presented with the "Consent to Participate in Research" form, they will be informed that identifiable data will not be used in any publications.

2. Will data be collected anonymously (i.e., no identifying information from subjects will be collected/ recorded that can be linked to the study data)? (NOTE: Data is not collected anonymously if there is a code linking it to personally identifiable information).

   Data will be collected confidentially but not anonymously. The completed surveys will be coded, excluding any code that links the data to personally identifiable information.

3. If using existing data/biological specimens, will the researchers have access to a code linking the data to personally identifiable information?

   Existing data/biological specimens will not be used in this study.

4. If identifying information will be collected and linked to data/specimens, explain at what stage identifiers will be removed from the data/specimens.

Identifiers will be separated from data at the time that the research conversation takes place. Each participant will be assigned a code, which will be used to identify notes that are taken during the conversation. A master sheet with names and codes will be kept securely and separate from the data. All data that could potentially be used to identify participants will not be included in publications.

5. If identifiers will be retained, explain why this is necessary and how confidentiality will be protected.

Confidentiality will be protected through the coding process described in the previous response. The codebook will be kept in a secure location as long as the information is needed. When the information is no longer needed, the identifiers will be properly disposed of.

6. If the data is coded, explain where the key to identifiers will be stored, how it will be protected, and who will have access to it.

A master sheet with names and codes will be kept securely and separate from the data. An electronic copy and a hard copy of the key will be maintained. The electronic copy will be stored in a protected file that only the lead and co-investigators will have access to. The hard copy will be mailed to Berkeley by the administrators of the survey in Panama and then locked in a secure file cabinet that only the lead and co-investigators will have access to.

7. Indicate whether research data/specimens will be destroyed at the end of the study. If data will not be destroyed, explain why, where, in what format, and for how long it will be retained.

At the end of the study, the data will not be destroyed. The data will be retained in hard copy in locked file cabinets and secured electronic format. The identifiable data will not be used in any publications, but the information will remain intact until no longer needed for future studies.

8. Explain how data collection instruments, audiotapes, videotapes, photographs, etc. will be stored and who will have access to them. Indicate at what point they will be transcribed and/or destroyed (if ever).

The physical surveys will be transcribed into electronic format and sent to the lead and co-investigators via email. They will then be mailed to the lead and co-investigators with the physical consent forms via postal mail.

NOTE: The CPHS does not require that researchers destroy their human subjects data at the completion of their research. *Whenever appropriate, researchers may retain study data for future use/ other research purposes as long as they make provision in the protocol and consent documents for such use.* Researchers must spell out in the protocol how confidentiality will be maintained vis-à-vis long-term storage of data and/or granting of access to other researchers, and the consent forms must clearly ask subjects for permissions in this regard.

- **HIPAA:** If any of the study data sources are covered entities under HIPAA (Health Insurance Portability and Accountability Act), explain what arrangements have been made to comply with the Privacy Rule regarding subjects' "protected health information." (See CPHS website for HIPAA guidance).

None of the study data sources are covered entities under HIPAA.

- **Reportable information:** If it is reasonably foreseeable that the study will collect information which state or federal law requires to be reported to other officials (e.g., child or elder abuse) and/or ethically requires action (e.g., suicidal ideation), discuss here and reference reporting requirements in consent documents.

No such information will be collected.

- **Certificate of Confidentiality:** In certain circumstances, researchers may plan to protect research records from subpoena by seeking a Certificate of Confidentiality (http://grants.nih.gov/grants/policy/coc/index.htm). If a Certificate of Confidentiality will be sought for this study, indicate here and reference in consent documents.

A Certificate of Confidentiality will not be sought for this study.

SECTION 12: FINANCIAL CONSIDERATIONS

- **Compensation/payment:** Describe plan for compensation of subjects by addressing points below. If no compensation will be provided, this should be stated.

  No compensation will be provided.

  - If subjects will be compensated for their participation, explain in detail about the amount and methods/ terms of payment.

    -Include any provisions for partial payment if subject withdraws before study is complete.

-When subjects are required to provide Social Security number in order to be paid, this data must be collected separately from consent documentation. If applicable, describe security measures that will be used to protect subject confidentiality.

N/A

- If non-monetary compensation (e.g., course credit, services) will be offered, explain how it will be provided.

N/A

- Discuss reasoning behind amount/method/terms of compensation, including appropriateness of compensation for the study population and avoiding undue influence to participate.

N/A

- **Costs to Subjects:** If applicable, describe any costs/charges which subjects or their insurance carriers will be expected to pay. (If there are no costs to subjects or their insurers, this should be stated.)

There are no costs to subjects or to their insurers for participating in this survey.

- **Treatment and Compensation for Injury:** *If the study involves more than minimal risk*, indicate that the researchers are familiar with and will follow University of California policy in this regard, and will use recommended wording on any consent forms (see CPHS Informed Consent Guidelines).

N/A

SECTION 13: ADVERSE EVENT MANAGEMENT/REPORTING

- Explain how unanticipated negative outcomes/experiences or serious adverse events will be managed. (NOTE: This may apply in social-behavioral as well as biomedical research (e.g., undue stress or anxiety of subject, breach of confidentiality via loss of laptap computer with study data.) Provisions should be made and described here *if applicable*.)

N/A

- Describe plans for provision of treatment for study-related injuries, and how costs of injury treatment will be covered (see “Treatment and Compensation for Injury” above).

N/A

- Discuss plans for reporting unanticipated or serious adverse events to CPHS (see CPHS Adverse Events). (This applies to all types of research.)

N/A

SECTION 14: ATTACHMENTS

- Please list all attachments (e.g., consent forms, survey instruments, recruitment materials, appendices) included with your submission.

– Survey
– Consent Form
– Lead Investigator's Certificate of Completion of CPHS Guidelines

Appendix VI: Correspondence with CPHS regarding survey approval

From Arriane Michas amichas@berkeley.edu

Dear Ms. Zaniewski,

I am an analyst in the Office for the Protection of Human Subjects here at Cal and I have been reviewing your application for exempt status. Several questions have come up which need some clarification.

1. Informed consent. As the human subjects with whom your study deals are indigenous Ngobe villagers, how will you insure informed consent? I see that you have translated your consent form into Spanish, but what approach will you take with villagers who are illiterate in Spanish? Also, it is unclear whether Ngobere has a written form. If subjects are fluent in only Ngobere, what provisions will you take to ensure that they are informed? And if Ngobere does have a written form and you translate the consent form into it, how will you ensure informed consent for those subjects who may be illiterate in that language?

2. Confidentiality. In your description of where you will store the data for this study you state that the key to identifiers will be stored in a protected electronic file in your personal computer(s), OR it will be kept in paper form, in Panama, under lock and key. Which is it?

3. Conflict of Interest. It appears from your description of your research that the data collected may be going to inform a product development process for products that may be sold back to the subjects involved in the study. Please elaborate on who is funding this study and what their stake in its outcomes are.

Thank you for taking the time to clarify these areas of your study. I look forward to your response.

Sincerely,

Ariane Michas, Analyst

OPHS

510 642 7462

Hi Ms Michas,
I hope these answers will be helpful:

1.Informed consent. As the human subjects with whom your study deals are indigenous Ngobe villagers, how will you insure informed consent? I see that you have translated your consent form into Spanish, but what approach will you take with villagers who are illiterate in Spanish? Also, it is unclear whether Ngobere has a written form. If subjects are fluent in only Ngobere, what provisions will you take to ensure that they are informed? And if Ngobere does have a written form and you translate the consent form into it, how will you ensure informed consent for those subjects who may be illiterate in that language?

Answer:

It is true that Ngobere does not have a standard written form (some attempts have been made to make one, but knowledge of written Ngobere is not common) and that many subjects may be illiterate. For that reason, we are having people who are locals administer the survey. All of the interviewers are Ngobe themselves, and fluent in Ngobere. The administrators will explain the consent form orally in Ngobere to the subjects who are Spanish illiterate.

2. Confidentiality. In your description of where you will store the data for this study you state that the key to identifiers will be stored in a protected electronic file in your personal computer(s), OR it will be kept in paper form, in Panama, under lock and key. Which is it?

The data will be tabulated by the local leader of the survey and sent to us electronically, where we will then store it in a protected file on a PC. The paper survey results will be kept by the local survey leader in Panama until we retrieve them when my teammate and I go to Panama this summer.

3. Conflict of Interest. It appears from your description of your research that the data collected may be going to inform a product development process for products that may be sold back to the subjects involved in the study. Please elaborate on who is funding this study and what their stake in its outcomes are.

We are using this data to study energy patterns of the people of Soloy, in order to make practical contibutions to reducing the economic burden that the energy use represents. For instance, the project we are working on now is designing efficient flashlights for the community. However, neither we nor our sponsor are going to be making a profit off of this- our intention is to bring our design to the community, and have community members run the project and assemble and sell the efficient flashlights. We will provide training in assembling and marketing the product, but the community members will ultimately be the benefiters. This will provide much needed entrepreneurial and employment opportunities for the community. We are operating off of a small grant from the Blum Center for Developing Economies, which promotes the university's involvement in global poverty issues. This project is simply about poverty reduction through providing entrepreneurial opportunities and reducing battery costs; the only people profiting will be the community members themselves.

I hope these answers are helpful. Please let me know if I need to clarify anything else.
Cheers
Anna

Dear Anna,

Thank you. This was very helpful. There is one more remaining omission in your application. Consent forms need to be submitted on UC Berkeley letterhead. If you could submit copies of the consent form in both English and Spanish on letterhead, that would be very helpful. Please send this to:

Ariane Michas

c/o OPHS

UC Mailcode: 5940

I'll let you know when I have received it and if there are any other outstanding issues, but that should be it. It sounds like a laudable project and I wish you success with your work.

All best,

Ariane

Hi Anna,

Thank you for bring that by. I received it this morning. Unfortunately there are still some critical pieces of information that are missing from your consent form. It needs to include:

The researcher's (your) address and telephone number

The address and phone number for CPHS.

The paragraph could read:

If you have any questions or concerns, you may contact the Lead Investigator or the Office for the Protection of Human Subjects

Principal Investigator: Your Name, tel:, email:

Office for the Protection of Human Subjects

University of California, Berkeley

2150 Shattuck Avenue

Suite 313

Berkeley, CA 94704-5940

(510) 642 7461

And you need to include date lines next to the signature lines.

I apologize for this repeat of yesterday's exercise. I have re-read your application and believe this to be the last outstanding piece before it is approved.

Best,

Ariane

Dear Anna,

Please find attached a letter detailing your approval for exemption status for your upcoming research. We wish you the best of luck with your study.

Best,

Ariane Michas, Analyst

OPHS

Appendix VII: Survey Exemption Approved

UNIVERSITY OF CALIFORNIA AT BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO

SAN FRANCISCO • SANTA BARBARA • SANTA CRUZ

OFFICE FOR THE PROTECTION OF HUMAN SUBJECTS
University of California, Berkeley
2150 Shattuck Avenue, Suite 313
Berkeley, CA 94704 -5940

(510) 642-7461
Fax: (510) 643-6272
Website: http://cphs.berkeley.edu
FWA#00006252

5/3/2007

ANNA ZANIEWSKI (azaniewski@berkeley.edu)
Physics
1601 Allston Way MC#
Berkeley, CA 94703

RE: **CPHS Protocol #2007-4-10**
"Energy Use and Solar Power in Ngobe Village" - Graduate Research - - Physics

Dear Ms. ZANIEWSKI:

Thank you for the statement and request for exemption that you submitted to the Committee for the above-referenced project. Your submission has been reviewed and granted exemption, as it satisfies the Committee's requirements under category 2 of the federal regulations. Accordingly, the project is exempt from full Committee review provided that there are no changes in the use of human subjects.

Please note that although your research has been deemed exempt from full committee and subcommittee review, you still have a responsibility to protect your subjects, and the research should be conducted in accordance with the principles of the Belmont Report. Download the Belmont Report at this link:
http://www.hhs.gov/ohrp/humansubjects/guidance/belmont.htm.

If you have any questions about this matter, please contact the OPHS staff at 642-7461; FAX 643-6272; E-Mail ophs@berkeley.edu.

Sincerely,

Malcolm Potts, M.B., BChir, Ph.D.
Chair, Committee for the Protection of Human Subjects
Bixby Professor, School of Public Health

MP: ATM

Cc: Professor ASHOK GADGIL (AJGadgil@lbl.gov)
Graduate Division - SID # 18406244 - (degrees@berkeley.edu)
Mary Baugh, SPO (marybau@berkeley.edu)
KIMBERLY LAU - SID# 16235343 (lauk@berkeley.edu)

Appendix VIII: Contact information for group members

ER291 Group:
Anna Zaniewski azaniewski@gmail.com 510-684-9487
Kimberly Lau lauk@berkeley.edu 415-994-3688

Mentors:
Ashok Gadgil ajgadgil@lbl.gov
Jonathan Slack jlslack@lbl.gov
Howdy Goudey CWGoudey@lbl.gov

New members:
Jed Deursch jduersch@gmail.com
Noelle Cole noellecc@berkeley.edu

New mentor:
Sara Beckman beckman@haas.berkeley.edu.

Local Contact:
Adan Bejerano Rios olorobo@hotmail.com