Socio-Economic Impacts of Solar Electricity in Rural Haiti

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PREFACE

The primary goal of this study was to understand what happens when a modest amount of solar electricity becomes available to rural Haitians. On Haiti, an island of 10 million people, 7 million people live without access to electricity. Many development initiatives are now focused on electrification as a means to improve quality of life and raise people out of poverty. This study seeks to understand those quality of life changes, both expected and unexpected, that electrification can bring to impoverished populations.

The genesis for this study arose out of a chance meeting between two energy professionals at TIDES 2013 (Transformative Innovation for Development and Emergency Support), a disaster recovery conference that showcases off-grid and sustainable technologies aimed at distressed populations of the world. The team that collaborated on this study also had backgrounds in anthropology, and were focused on conducting an analysis of electrification that reached beyond economy and technology, into the phenomena of social change.

The information encapsulated in this report should be considered exploratory. The data-gathering portion of the project took place over a 10-day period, with two days of interviewing on the island of Ile a Vache, two days in the coastal town St. Helene, and one day in the city of Leogane, about an hour away from the capital city of Port au Prince. Thanks to the openness and cooperation of our respondents, we were able to gather much data that we believe will help us better understand the effects of solar energy projects like the one introduced to these three communities by the Sirona Foundation.

We encountered some of the typical limitations including insufficient time to conduct interviews, the language barrier between the interviewers and participants, the challenges of having multiple translators, but believe that we were still able to collect useful and valuable data.

It is the hope of the authors of this report that we, or others who choose to study models of electrification, will be able to take our initial lines of questioning and expand and improve upon them.

ACKNOWLEGEMENTS

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Special thanks to Michelle Lacourciere and Sirona Cares Foundation, who graciously provided us with access to their electricity program participants.

We are also indebted to those who supported us in-country and went above and beyond to ensure that our time in Haiti was wonderfully smooth and productive - Fabienne Valmond, our colleague at George Mason University who generously volunteered her time as our translator, and Thys for his translation and daily support of our interview work, and Jacqueline for organizing our itinerary and providing for our safe travels.

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SECTION 1: AT A GLANCE

ABOUT THIS STUDY

This study is the beginning of an inquiry into how everyday life changes for rural Haitians when a modest amount of solar electricity becomes available to them for the first time. We focused on quality of life indicators such as education, health, economics, environment, and leisure and social relations. Our goal was to better understand how this change is experienced by rural Haitians and uncover the spectrum of intended and unintended outcomes.

Electricity in Haiti

In recent years in Haiti, development organizations have been implementing electricity programs with the intention of raising the standard of living in rural, agriculture-based communities. Haiti is one of the poorest countries in the western hemisphere, and has the lowest level of electrification in the Americas, at less than thirty percent of the population. This means 7 million of the 10 million people on the island live without access to power. The Haitian government believes that lack of access to electricity constitutes a major limitation to economic development and to the population's quality of life. The government is seeking to increase production, transportation and distribution of electricity, as well as improve the commercialization of electricity and facilitate development of the country's renewable energy capacities.

Sirona Cares' Rural Electrification System

Sirona Cares is a non-profit foundation whose mission is to bring solar electricity to homes not reached by government utilities. Since 2010, Sirona has been supplying rural Haitian villages with a solar unit called a SunBlazer, which collects solar energy to create electricity that charges battery packs that residents can then carry back to their homes for lighting and cell phone charging.

Pictured: Sirona Solar Trailer "SunBlazer" Unit

The battery packs, supply 2 LED bulbs, USB port for cell phone charging, and a flashlight.

Pictured: Sirona Battery Packs "Ty Soley" and Charging Station

Thus far, Sirona has implemented systems in 14 Haitian villages with the goal of providing electricity to 1 million rural Haitians by 2020.

Study Objectives

The study sought to answer a broad, core question: How does everyday life change when a modest amount of solar electricity becomes available to a group of people for the first time? The data gathered will help to define a quality of life baseline and also provide evidence of impact and sustainability.

We focused on quality of life impact indicators such as:

- Economics
- Education
- Health and Safety
- Environment
- Leisure and Social Relations

We used ethnographic methods of observation and interviewing techniques for our on-site research. We gathered both quantitative and qualitative data to ensure that we can show quantifiable impacts but also share more personal accounts of the impacts of electrification.

We completed over 80 interviews and 2 focus groups in 3 villages in rural South Haiti:

- Ile a Vache - Baseline, Non- Electrified Village
- St. Helene - Electrified with a SunBlazer for 4 months
- Leogane - Electrified with a Sunblazer for 2 years

Key Findings

Themes in key impact areas emerged. One of the most surprising findings was how much benefit came out of a modest amount of electricity.

Access to electricity, to power two LED light bulbs, a flash light and a USB port to charge a cell phone, fostered entrepreneurial growth and allowed villagers to increase their productivity. When villagers no longer had to rely on the polluting fuels of diesel and kerosene, observable health improvements were possible and there was less harm to the physical environment.

Villagers believe that lighting has improved their lives through healthier living from a smoke free environment, better educational opportunities for their children due to the extended day for studying, additional opportunities for leisure and leisure activities such as radio and television, and increased opportunities to expand their work, and earn a better living. Several villagers expressed that the effect on their quality of life outweighed any money they could hope to generate or save by using the solar kits. One of our participants commented that "now I feel like a human being" after being given electricity. (See p. 24, St. Helene - Ethnographic Profiles, for this respondent's story.)

On the spectrum of unintended consequences, many people worked longer hours and women seemed to have even less time for leisure. Also, people were negatively impacted by travel time and transportation costs to go to and from the charging station.

Sirona's Sunblazer system was structured to keep the cost of the service equivalent to, or if possible lower than, the cost of fuel and candles for light and the cost of charging cell phones. In this respect, Sirona's system has largely been successful by keeping the cost approximately 10% below current energy costs for village households.

Sirona's success in impoverished Haitian villages, which are some of the poorest in the world, also prove that solar energy is economically viable for low-income communities living without electricity.

SECTION 2: KEY IMPACTS

This section covers our findings in more detail, focusing on key impact areas of education, livelihood and economics, health and safety, environment, and leisure and social relations.

Table 1 provides a quick snapshot of the key study areas and impacts.

There was a positive effect on health, safety, education, and home environment and a mixed effect on income, leisure time, local environment and social relations.

Table 1: Key Study Areas and Impacts

Impact Area	Positive	Neutral/Mixed
Education		
Economic		
Health and Safety		
Environment		
Leisure & Social Relations		

Each of these areas are discussed in greater detail on the following pages

2.1 IMPACT ON EDUCATION

Education is a key component of improving opportunities for a better life and better jobs in impoverished communities. Literacy rates in Haiti are extremely low with only about 50% of the population being able to read and write adequately.

Pictured: Children studying by Light

The Haitians we interviewed place high value on education and are very focused on providing better education opportunities for their children. In Ile a Vache, the hope that access to light would encourage more study time and better intellectual development in the children was often expressed. One person stated that "kids mind will be changed...the way they think is different than children who have electricity."

Resoundingly, according to the parents and teachers in St. Helene and Leogane, children were studying longer, doing their homework,

were better prepared for school and getting better grades. Study times, on average increased 30-60 minutes per day. The light was used to study in the evening hours, often in groups. Parents were happy that the children did not have to come home from school and study immediately - they could take a rest, eat dinner, and then study. Before electricity, days were compressed due to a lack of light; children often went to school from 9-3 and study then eat and go to bed. Participants also reported a positive effect on childrens' eyes, as the dim and smoky light of kerosene had caused constant eye irritation.

In the lighted villages, we noticed an increased exploration of media such as radio, portable DVD players, and TV. Even without access to the Internet, access to media is an important way that villagers (especially women and girls) become aware of social issues.

"Kerosene has a bad effect on eyes. Children have access to more information, can listen to news, and that changes their mind. Now they wait for dinner and are awake - we used to have to wake them up for dinner."
– Teacher, St. Helene

2.2 IMPACT ON LIVELIHOOD (ECONOMICS)

Pictured above: A Homemade Kerosene lamp called "Tet Gridap" in Ile a Vache

For electrification initiatives to successful, even the most impoverished must be able to afford to pay for electricity, which means the cost of using electricity must be equal to or lesser than current energy costs. According to the World Bank, over half of Haiti's population of 10 million lives on less than US$1 per day, and approximately 80% live on less than US$2 per day. This means that electricity rates must cost the average Haitian far less than US$1 per day.

Sirona's goal with their kits is to offset the cost of kerosene, diesel, batteries, candles and cell phone charging. This means that people would pay an equal or lesser amount for the Sirona lighting solution than for these other forms of light and energy. The cost of a Sirona battery pack in Haiti is approximately $6 per month which equals approximately $.20 cents per day for the average Haitian family, which approximately 20% of their daily income.

Impact on Living Expenses:

Our analysis shows that Sirona's system is saving residents of St. Helene and Leogane approximately 10% per month on what they normally spend on energy over Ile a Vache residents who, because they do not have electricity, spend more on kerosene, cell phone charging and batteries. We believe that Sirona could potentially save residents 20-30% if the kits are functioning properly, at their full capacity.

Sirona clearly saved clients money that would have been spent on kerosene, candles, and batteries, however, only if they did not have to pay for taxi services or buy gas for a long trip to the operator's station. We found that respondents who did have to spend money on taxis or fuel for a car trip to maintain the service were not saving money on energy costs. A comparison of energy expenditures by village including cost savings from the Sirona Kit is provided in Table 2 below.

Table 2: A Comparison of Energy Expenditures by Village

Energy Expenditures (in Haitian Gourdes)	Ile a Vache	St. Helene	Leogane
Sirona Kit	0	264	264
Kerosene	250	50	50
Cell	100	40	40
Batteries	80	20	20
Candles		10	10
Total Energy Costs Per Month	430	384	384
SAVINGS with SIRONA		46	46

Currency Conversion: 44 HTG (Haitian Gourdes) = 1 USD

The costs of kerosene consumes almost 60% of the energy expenditures for the typical rural resident in Ile a Vache. Also, the costs to charge their cell phone are over 25% of the budget as they pay for the charge and also for the transportation to and from the charging station.

A total of 6 people in Leogane and St. Helene stated that they pay 50 HTG to travel twice per week to charge kits.

Table 3: Travel plus Energy Expenditures by Village

Energy Expenditures (in Haitian Gourdes)	Ile a Vache	St. Helene	Leogane
Total Energy Costs Per Month	430	384	384
Costs of Traveling to Sirona Charging Station (per mo. *)		300	300
Total Costs Per Month for Energy including Travel	430	684	684

Residents travel round-trip by foot an average of 45 minutes, with 10 minutes being the lowest travel time, and 3 hours being the longest travel time. Charging trips in Leogane occurred daily on average, while in St. Helene, charging trips were averaging every 3 days. Impacts that have yet to be measured also include lost productivity as a result of travel time.

People were willing to travel a great distance, at an additional expense to recharge their batteries. Our conclusion is that the improvements to their quality of life outweighed the economic hit customers took to obtain and keep the kit. Therefore, in order for Sirona to fully realize its goal of helping customers redirect money saved into their family and local economies, its services must become A) more easily accessible or B) more widely available.

Productivity Effects: There is a broad range of occupations in Haiti including farmer (raising both animals and crops), teacher, vendor (selling sodas, breads, charcoal), tailors, preachers, furniture makers, and even bone setters. Most people had more than one job, and often must have 3 to 4 jobs in order to earn a daily living. Small business entrepreneurs account for 40-50% of the village occupations, with farmers being the second largest occupational group.

We found mixed outcomes on income improvements - whether you were able to earn more was normally determined by the type of work you do. Small business operators such as tailors, furniture makers, sellers of produce, drinks or other tangible products (40%-50% of the respondents) benefited from having their days extend into the night with light.

Entrepreneurs tended to feel less rushed during the day to complete their work - some extended their work hours up to 5 hours longer per day. However, farmers who raised either crops or animals did not note greater productivity. Most of their work of tending animals and caring for crops, is done during daylight so they did not see an increase in working hours. This means that this small amount of electricity did make some people more productive; however, only because it extended their day, not because they were able to be more efficient by using the electricity for tools or machines. The Sirona battery pack did not provide enough power to run larger appliances or machinery.

Pictured below: Furniture Makers Shop in St. Helene

"Having electricity has made us better off economically - I can sell more at night. When people see light at the house, they come to buy."
– Soda Vendor, St. Helene

2.3 IMPACT ON HEALTH AND SAFETY

Pictured: Two Young Residents of Ile a Vache

Impact on Health

According to USAID's 2007 study, Environmental Vulnerability in Haiti: Findings and Recommendations, it is estimated that the average life span in Haiti is shortened by 6.6 years due to the impacts of indoor air pollution caused by burning biomass indoors. Acute Lower Respiratory Illness (ALRI) is the number one killer of children under five in Haiti (as it is worldwide.)

In Ile a Vache, we observed children with red eyes and persistent coughs. Parents often said that their children had trouble studying by the dim light of the lamps. Dark, soot covered ceilings in homes were the norm, as were frequent washings of clothes due to the smoke from the lamps. People talked about the "black" that coats the inside of their noses.

" The sun is already like a vitamin for our health, the solar energy provides lighting, health, and electricity
– Parent and Teacher, St. Helene

The villagers were well-educated on the negative health and environmental effects of the lamp but did not have any choice but to burn kerosene, diesel, charcoal and wood.

In the electrified villages, their eyes felt much better, and they were no longer breathing a lamp full of kerosene smoke - the equivalent of smoking 40 cigarettes per day.

Having LED lighting provided by the Sirona kit eliminated the use of the kerosene lamp for lighting in 65-70% of the households we interviewed in St. Helene and Leogane. Reduced use of kerosene indoors meant villagers no longer had smoke irritating their eyes and soiling their clothes. Also, the ceilings in their homes were not black from soot, nor did black dust line their nostrils or get into their lungs.

Statistics on Indoor Air Pollution

About 20% of the world's population use fuel lamps.

77 billion liters of liquid fuel, mostly kerosene, are used annually to light houses without electricity.

4 million people annually die prematurely from indoor air pollution caused by burning fuels, coal and biomass.

Lamp fuel often yields black carbon that absorbs light, thereby heating the atmosphere.

Lamp fuel often yields black carbon that absorbs light, thereby heating the atmosphere.

While the Sirona kits did not completely eliminate the use of kerosene, it did reduce kerosene use significantly from 1 gallon per month to approximately 20 ounces per month; this is an 85% reduction. One respondent in Leogane who had returned his malfunctioning kit said he did not begin using the lamp after giving up service; rather, he used candles. He felt he could not go back to the polluting soot that kerosene creates. Also, people kept kerosene around for backup lighting, in case their Sirona battery ran down, or they needed to use light outside of their homes.

IMPACT ON SAFETY

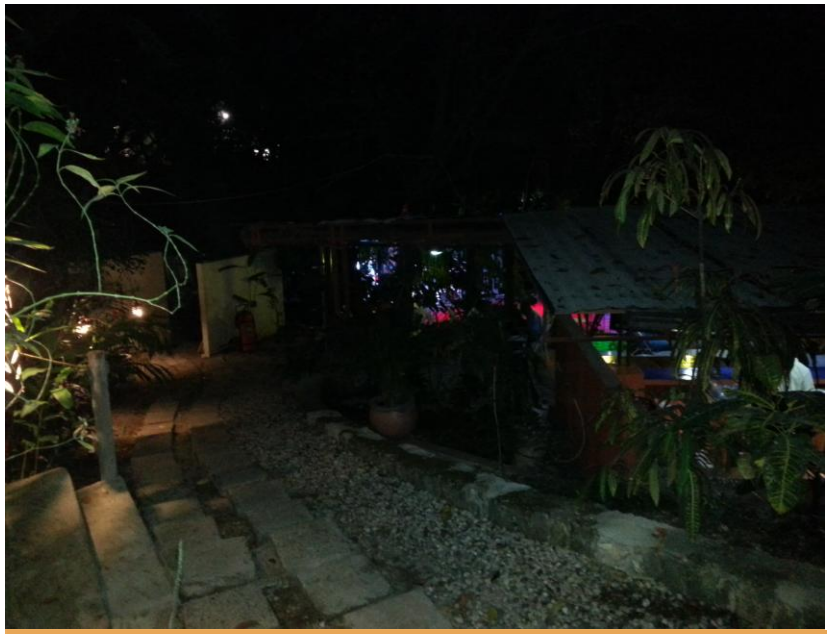
During winter months, the sun sets in Haiti around 5pm after which there is a deep darkness. With many activities, such as playing dominos, occurring after dark, people need lighting to help them travel safely to other homes or to the main village gathering area for evening events. In most rural villages in Haiti, homes are scattered widely across mountainsides and valleys.

The terrain is often steep and rocky making walking, even during the day, challenging. Lighting allows people to see where they are walking at night and to feel safe walking around. People often used flashlights or cell phones to light their way. We observed the Sirona LED lights were often placed outside the home to illuminate the area around the home. People expressed a greater feeling of ease and safety with the lights and they were happy that they could see around them, both in their homes and outside.

The light often drew people to homes and gatherings were now more frequent in the evenings. They also mentioned that they felt safer at night walking around, and believed that the community was safer with lighting.

> **"The system can alert you when something bad is happening in your area**
> – Homemaker, Leogane

One of our Leogane respondents drew a link between lighting and personal safety and commented that "bad things that could have happened, haven't happened."



Pictured: Lit Pathway

With respect to safety hazards, concern over house fires occurring with the commonly used glass lamps and candles in the home was often expressed. The open flame, the flammability of the liquid and also the fragileness of the glass made it dangerous to use, especially for children. Several people mentioned incidents in which children had knocked over lamps and harmed themselves or burned the home down. Burns are very common.

Villagers seemed relieved to have the Sirona kit and felt that having electricity was much safer than having lighted lamps or candles.

Statistics on Safety of Kerosene

Many studies report that accidental ingestion of kerosene is the primary cause of child poisoning in the developing world.

1000s of people, especially children and even infants are injured, burned or lose property each year due to kerosene-related fires.

2.4 IMPACT ON ENVIRONMENT

Pictured: Typical Haitian Kitchen with 3 stones and wood for cooking

We defined environment as the impact on the broader physical environment. This means that we were looking at environmental impacts that might affect people both inside their homes and outside their homes.

Indoor Environmental Impacts

As mentioned previously, the use of kerosene and diesel in homes was significantly decreased with the Sirona kit. This translates into much less indoor air pollution in the form of soot flowing through homes, into lungs, onto clothes and furniture. People expressed satisfaction with their personal cleanliness and women felt like they had "more control over the house," meaning that they could see into every part of their home, and it was easier to keep it clean and tidy

> **"Light is very important for human beings and Sirona comes out and provides light to everyone. I think there's a link between light and safety"**
> – Homemaker, Leogane

and to know what everyone is doing.

Impact on Local Environment

We were also hoping to see that the lighting had an impact on the use of wood and charcoal as deforestation is a major problem in Haiti. It did not - people continued to use the wood and charcoal for cooking and ironing in the same amounts as they had before. Many participants mentioned that they would really like to have a stove - either electric or propane, and also a refrigerator to store food. They must cook every meal as food cannot be stored.

Kerosene Air Pollution Fact

About 22.38 pounds of CO2 are produced by burning a gallon of diesel fuel. This means that the Sirona lamp reduced home Carbon Dioxide emissions by at least 65%

2.5 IMPACTS ON LEISURE TIME

Pictured: Woman Washing Clothes in Leogane

Leisure time in Haiti is often used for socializing within the village, listening to music, playing games such as dominos, and going to church. Evenings and weekends are typically when Haitians will take a break from daily activities and responsibilities.

We had mixed results when we asked participants in the two electrified villages (St. Helene and Leogane) about how having electricity had affected their leisure time. In St. Helene, out of [how many?] respondents, 30 percent said they had more leisure time, 23 percent said they worked more, and 42 percent said that they had about the same amount of time.

In Leogane, out of the 9 people who responded to the question of more time, 6 said they had more leisure time and 3 said they had a longer work day as a result of having the kit. Women seemed to have less leisure time than men, as their leisure time actually decreased as they continued to do chores into the night. One woman stated that "I work more, only when I sleep do I rest." She believes electricity makes them work more.

"Because my house is on the main street, I can watch people go by now, children are happier, stay up later, play into night"
– Vendor, St. Helene.

With women's domain being the house, chores continue as long as light is available. Men were primarily responsible for farming and, especially, for heavy work, such as tilling. Men's chores, as culturally conceived, are usually tasks conducted outside and tied to the rising and setting of the sun. Women's labor, even when it takes them outside, is still tied to the home.

Seven of our respondents indicated that the kits allowed them to "follow" their children while they worked. We took this to mean that they could easily see where the children were and what they were doing at all times and so were able to better assist or monitor their childrens' activities.

With electricity, the day was often extended by 2-4 hours, reducing sleeping hours. Bedtime before electricity tended to be around 6 or 7 and after electricity, around 9 or 10. Reported bedtimes in Leogane tended to be slightly later than in St. Helene—between 10 PM and midnight.

Many participants with electricity stated that they had more time to do things such as complete chores for the next day, socialize with friends, watch their DVD player, or read. When we interviewed in the

village of Ile a Vache, most people were in bed by 6 or 7pm. Sex was the most frequent activity cited after dark. This often means increased fertility and pregnancies. We did ask about lighting's effect on sex, and one man stated it had none, they just turned out the light. We were not able to draw confident conclusions about lighting's full effects on sexuality and fertility as our study period was condensed. However, the findings we did obtain indicate that it may be a ripe area for further investigation.

SECTION 3: ABOUT SIRONA CARES FOUNDATION

Background

In 2010, a U.S. non-profit called Sirona Cares (http://www.sironacares.org) partnered with the IEEE's Community Solutions Initiative (http://communitysolutionsinitiative.org) to create the IEEE/Sirona Rural Electricity Program. The Community Solutions Initiative creates energy solutions for the world's poorest people. They provide open source solar energy solutions and donations of equipment to pilot new initiatives in developing countries.

Sirona's Business Model

Local operators are selected by Sirona Haiti to implement the solar solution in their village. They receive a 1.5kW solar generating unit capable of supplying recharge services to 80-100 home customers and portable battery kits for up to 100 homes.

The operator leases the equipment from Sirona and pays a monthly leasing fee of $300 USD to Sirona. They can sign up 100 villagers to receive the service, and charge each of them $6 per month for a portable battery pack (called a Ty Soley kit meaning "little sun" in Haitian creole) which can be recharged as many times as needed during the month by plugging into the solar unit. Recharge time is 3 hours per kit, and 20 kits can be charged at a time.

Pictured: Battery Pack "Ti Soley"

The electrification program in rural Haiti was created to be community driven and to enable Haitians to be more self-sufficient. The electricity for each home was intended to be equal or lower in cost compared to what residents would otherwise spend on kerosene, batteries, candles, and cell phone charging.

Sirona's program is supported by Haiti's Ministry of Public Works because it complements, rather than competes with, Electricité d'Haiti, the national electric utility by providing isolated communities with electricity and getting customers used to the idea of paying for electricity.

To enable sustainability, the program is necessarily run as a business rather than a charity, so in 2012 Sirona Haiti, S.A. was formed. This

Haitian corporation is run as a social enterprise reinvesting profits into expansion of the program.

Currently, Sirona is operating in 14 villages in Haiti and expanding to 31 additional sites (3,100 more homes in 2014). Sirona's long term goal is to bring their lighting solution to 1 million Haitians by 2020.

Funding

Sirona began operations with equipment designed and donated by the IEEE. This initial equipment and the subsequent repairs and retrofits provided by the IEEE, (worth several hundred thousands of dollars) enabled Sirona to pilot the program in rural Haiti. Following the pilot units, funding for Sirona Cares was provided in the form of grants from USAID and the United Nations Environmental Program. These grants funded the equipment for the expansion of Sirona's work in Haiti. Operational expenses are met by collecting the $6 per month for the battery packs from the homeowners, half of which goes back to Sirona Foundation to fund the service and maintenance of equipment and continue development and expansion of the program. The other half of the revenue is kept by the local operator.

Sirona is transitioning to a commercial model of operation by making the units available to any qualifying organization. The mobile solar units with 100 Ti Soley kits can be purchased by an organization for approximately $25,000 USD. Sirona works with the purchasing organization from program inception to set a monthly rental price for the battery packs and they keep the entire amount of the revenue generated and also choose how much goes to the village operator. Sirona will train the purchasing partner on all aspects of their sustainable business plan. Payback from the monthly battery pack rental charges is expected to occur in year five. The assumed life of the units is approximately ten years.

The model is meant to be a sustainable long-term revenue source for a community organization with the funds staying locally and employing people in the community to be operators and technicians.

The model has proven to be economically viable in the impoverished areas of Haiti, keeping energy costs less than a families current expenditures, and helping families adopt to paying monthly for electricity.

SECTION 4: ELECTRIFICATION IN HAITI

Background

Haiti briefly found itself in the spotlight on the international stage in 2010, when a 7.0 magnitude earthquake struck the capital city, its suburbs, and the nearby city of Leogane (the epicenter of the quake.) Prior to the disaster, electricity was a luxury even among residents of Port-au-Prince, which historically has always been much more developed than the rest of the country. Seventy to eighty percent of the population of Haiti did not have regular access to electricity. After the earthquake the figure rose to about 90 percent.

We observed that wealth, prosperity, and the ability to earn a living are deeply tied to energy flow and access to energy. The wealthiest are mostly living in urban environments in Haiti - places like Port au Prince, Port Salut, Les Cayes all have fairly vibrant economies, professional jobs, and a somewhat reliable energy supply. Most people also have batteries and generators at their disposal when the electricity goes out, so they can continue to operate their businesses and enjoy the comforts of their home. Because most of Haiti's transmission infrastructure is concentrated in the larger cities and along the 2 main roadways through the country, the majority of the country has little access to the supply. If you live along a roadway, you can often secure service - however, even a few 100 yards off the roadway, it is difficult to get an electricity line to your home. Nonetheless, with 80% of the Haitian people (8 million people) living in poverty most cannot afford the national utility rates.

Haiti's national electrical utility is called Electricité d'Haiti (EDH). Since the organization was established, little has been done to maintain existing infrastructure or to expand it. EDH is able to provide electricity to only a small percentage of Haitians—about 12 percent of 10 million inhabitants by official estimates, but accounting for those who tap in illegally puts estimates closer to 25 percent (Tate 2012). On average, customers (paying or otherwise) might receive 10 hours of light per day, but blackouts and brownouts are frequent. When the earthquake struck Haiti in 2010, EDH's director-general, Serge Raphael, estimated it would require $40 million just to return the country's electrical infrastructure to its pre-quake status (NBC 2010). In 2011 the International Development Bank made a grant of $20 million to Haiti's energy sector, but it remains to be seen what the results of the project will be. Even if it is successful at overhauling Haiti's national utility, the fact remains that only Haitians who have access to EDH's transmission lines will see the benefit of it. Rural sites like the ones discussed in this study will continue to be neglected.

4.1 ELECTRIFICATION IN RURAL HAITI, BY VILLAGE

Summary

While we found many of the effects of solar electrification to be similar across villages, there were also many differences in the ways each village experienced electrification due to their geographical location, their proximity to commerce, and their previous experiences and expectations of electricity.

Interview Environment and Logistics

Our observations and interviews were affected by the style and environment in each village where the study was conducted.

The three sites represented beginning, middle, and late stages of integration of a new technology or product. On Ile a Vache, a village without electricity, we had the opportunity to hear people's ideas about how having the solar home kits would change their lives, and we formed a picture of what life was like in the absence of solar electricity (or, more correctly put, very limited access to basic on-grid or off-grid electric services).

In St. Helene, where Sirona had been present for a year at the time of our assessment, the novelty of the product had yet to wear off, but some of its limitations were becoming visible. In Leogane, respondents were frank about their frustrations with defective kits and long waits for replacements. Responses from St. Helene and Leogane were very similar on two points: 1) that they believed that the price was too high despite Sirona's efforts to keep the price affordable, and 2) that despite the malfunctioning kits and their struggles to meet the cost of the kits, they did not want to be without the service again.

Ile a Vache—Baseline Unelectrified Village

Ile a Vache is a small island located off Haiti's southern coast. It takes approximately half an hour to cross the channel between it and the city of Les Cayes on the opposite shore. There are few job opportunities on the island, with a few small resorts providing the bulk of steady employment. Unemployment is high, especially among women. It was on this island that we conducted interviews in a small village on the western side. (While information we gathered at this site is likely generalizable to most of the island, until more information is gathered for future studies should take care not to rely too heavily on assumptions made based on data collected at this one location for this singular study.)

Our accommodations kept us near our respondents—a twenty to thirty minute walk up and down hilly dirt paths that became almost cement-like during heavy rains. Our hosts were members of the community we were concerned with, and in a two-day period we were able to build a rapport with several individuals outside of an interview setting.

Some of our respondents worked at the nearby hotel in Port Morgan, or at the nearby beachfront resort. A number of villagers worked as farmers, although the number of self-reported farmers was significantly lower than reported at the second of our three sites, St. Helene. (It should be noted that a majority of participants maintained some sort of home garden to supplement their supply of food; many also grew vegetables and raised livestock to sell.) The most frequently cited source of income was "small business." Small business takes the form of cooking and selling food, catching and selling fish caught in local waters, or buying household items,

cosmetics, charcoal, or foodstuffs and reselling them in local markets or at markets in Les Cayes. One male respondent worked as a boat taxi captain. Another male respondent was a professional plumber. Two respondents said they were unemployed at the time of the interviews.

Pictured: Ile a Vache woman holding a "lamp ver" or kerosene lamp

Since this location has no access to EDH electricity (or any other electrical grid), it provided an excellent baseline against which to compare our two electrified locations. A kerosene lamp was the most common form of lighting. A few respondents had access to light or electricity via a small individual solar panel, or solar-powered lamps and cell phone chargers, but these devices were not widespread, and were very limited in the power and light they were able to provide. The resorts on the island had their own electricity produced from diesel generators and were very helpful to the community in allowing them to charge cell phones on their premises.

The majority of our respondents used kerosene lamps to light their homes. While some had a lamp ver (a glass lamp of the sort commonly seen in rural areas all over the world, particularly in Asia and Africa, where electricity is not readily available), most used a homemade type of lamp called a tet gridap, made with a tin can into which was stuffed a wick of some absorbent material, like the one shown in the photo on this page. Interestingly, materials used for wicks were most likely not cotton, as our respondents reported that they were no longer able to raise or buy cotton.

Charcoal, wood, and sometimes coconut husks (the use of coconut husks was reported both in one of our initial focus groups, as well as in individual interview sessions) were the main cooking fuels. In rural Haiti, kitchens are often a separate outbuilding, and cooking is done over a fire built in the middle of three relatively flat stones, upon which a pot or pan can be set (see the section on St. Helene for a photo of a typical kitchen outbuilding and fire pit).

In terms of electric and electronic devices, cell phones were most ubiquitous. Those who did not own a cell phone themselves could borrow from a family member or friend when necessary. Equally ubiquitous was the radio, usually battery-powered. Only one of our 41 Ile a Vache respondents reported owning a television. Two reported owning a portable DVD player.

The carrying-out of work, household tasks, and school work revolved around the setting of the sun. There is the danger of walking rocky, sometimes muddy, footpaths after dark, as well as the difficulty of completing simple tasks in the house without being able to see beyond the small circle of light provided by a smoky, dim tet gridap. Even a glass lamp, while less polluting, still doesn't burn brightly enough to see far. Imagine, too, the difficulty of completing homework assignments with a child, or sometimes multiple siblings, gathered around one lamp.

For this reason, residents of Ile a Vache rose with the sun around 6 AM, in order to "maximize their day," as one respondent described it. Work and studying were compressed into the afternoon hours, and children ideally began their homework immediately after school, with no time to take a break. All agricultural work ended at dusk, around 6 PM. Some residents with small home businesses closed an hour or two after dark, prolonging their hours with the smoky kerosene lamp. Almost all residents reported bedtimes between 7 and 9 PM. Of our 41 participants, most said they had one to two hours of leisure time, during which activities included playing games (card games, dominoes, or board games), talking with friends and family, having sex, religious activities such as attending church or praying, and playing sports.

The average Ile a Vache resident spent around 200-250 Haitian gourdes (hereafter written as "HTG"; 250 HTG is about 5.59USD) on charcoal, 200-250 HTG on kerosene, 10- 25 HTG to charge cell phones which may only last for 3-7 days and 70 HTG for a month's worth of batteries. Because Sirona's solution mostly offsets lighting, cell phone and flashlight costs, without Sirona, average costs by village are outlined in Table 1 above. Ile a Vache residents were willing to pay approximately 100 HTG per month for lighting. Their expected costs for lighting were what their relatives in Les Cayes were paying EDH for electricity.

Ile a Vache - Ethnographic Profile

R., a woman in her early thirties, was born on the island and moved to Port-au-Prince when she was eleven. It was the 2010 earthquake, that specter that now hangs above the lives of Haitians, that motivated her return to Ile a Vache. She was in the kitchen of her house in PAP when the earthquake happened, and took all the kids under her bed to protect them. The event left her family on the street for two weeks. Her home destroyed, she left behind her partner at the time and all of her possessions, including all her electric and electronic devices, and returned to Ile a Vache. Four years on, she had a husband (a man she met on Ile a Vache) and a young child, and was caring for two other children that were not biologically her own. She had much to say about the state of the island community, particularly the lack of employment for women. She was unemployed herself at the time of our interview because of pregnancy, but before becoming pregnant she worked part time for Port Morgan Hotel, the largest employer on the island. She also had strong opinions about what solar energy services provided by Sirona could do for the communities of Ile a Vache. She had seen the batteries and thought they would work well. Even if they didn't have lights for the streets, she said, it would be good, even though street light is important too. Just one light would be sufficient for the house. At the time she participated in our project, she relied on kerosene and flashlights, and like all of our participants, she cooked with charcoal. When asked how much she paid for all fuels and batteries required for her daily life, she said her family spent 200 gourdes per gallon of kerosene, 200 gourdes for a bag of charcoal that would last 8-15 days, and 70 gourdes for a month's supply of batteries. Like many island residents, she sent her cell phone up to Port Morgan to be charged. Presumably her husband, an employee at the hotel, carried her phone with him to work and charged it during the hours he worked.

St. Helene - Electrified Village 1

St. Helene is a settlement about 20 minutes from the town of Port Salut by car and 1 hour from Les Cayes. The road was treacherous once off the main highway. Huge dips in the earth, and standing water from two days of rain, meant the road was almost impassable in anything but a Land Cruiser.

The village had cement complex comprised of a schoolhouse, a half finished library and a courtyard. St. Helene had received a Sirona Sunblazer unit approximately 4 months prior to our arrival, which allowed us to study the short-term effects of electrification.

St. Helene represented something of a middle ground between Ile a Vache and Leogane. We stayed in nearby Port Salut, but our interactions with respondents were confined to the interview format. We interviewed for two days, the same amount of time as on Ile a Vache, but rather than meeting people at or near their homes, we met them at the home of the operator, P. P's concrete and tin roof house was right next to the community center, which had a schoolhouse, an unfinished concrete building, and a courtyard with benches arranged in a circle. In addition to serving as St. Helene's operator, P. was also a local leader who was simultaneously taking long-distance graduate courses through the university at Jeremie while studying to become a minister. He told us that the unfinished building would one day be the community's library. He hoped that one day it would be full of books and computers, complete with a wifi connection. His end goal was to provide a central point for information access. Between his family's home and the future library stood the solar trailer, with battery packs charging inside.

In this village, there seemed to be many more people employed in occupations in comparison to Ile a Vache. Of our 34 respondents from this location, 16 described themselves as farmers and 11 said they raised animals; of this combined group, nine did both. Twelve worked a trade such as construction, wood-working, stonemasonry, or tailoring; one of these respondents repaired motorcycles. Nineteen reported working multiple jobs falling into any number of the categories listed here. By and large, the women in the village had small businesses and a means of earning an income. The one person who reported having no employment or self-generated source of income was a student working to complete her secondary education.

Costs of fuel remained about the same as on Ile a Vache: around 225 HTG for a gallon of kerosene which lasted from 15-30 days. The majority of respondents now only use Sirona for lighting, but a few still supplemented Sirona with a kerosene lamp. One of the respondents who said he still used the kerosene lamp for some tasks said he was able to buy it by the quart now, instead of the gallon, so the cost of kerosene even for those still using it was reduced significantly. The cost of charging cell phones had been approximately 10 HTG each time but we were not able to obtain good data on how often they were charging their phones. In St. Helene, they walked or rode (by motorcycle) an average of 22 minutes, one way, to charge their Sirona battery kit. The frequency of their charging trip ranged between 1-7 days with 3 days being the average.

Pictured: Sirona Light Kit in a home in St. Helene

As in Ile a Vache, the majority of interviewees either owned a phone or had a friend or family member who had a phone they could borrow. Almost all had radios as well. However, four said they owned a TV, compared with the single respondent in Ile a Vache who reported owning one.

Use of kerosene lamps dropped steeply in the group of people we interviewed. Fourteen respondents specifically reported that they no longer used the kerosene lamp for any reason now that they had service through Sirona. Eight respondents indicated they still used the kerosene lamps at times; three said they used kerosene lamps while working outside, two said they or their spouses used the lamp when cooking, two said they used both the battery kit and the lamp, and one specifically said they sometimes used gas so that the light from Sirona would last longer. One respondent no longer had Sirona and was completely reliant on kerosene again. He indicated that this was due to the combination of a malfunctioning kit and a lack of money to begin paying for the service again, but said that when he had more money and could receive a replacement kit he would be willing to try it again.

Thirteen respondents used the battery kit, but did not specifically indicate that they used no gas at all. One respondent said she kept a small bottle (about the size of a 20 oz. soda bottle) of gas "for emergencies," presumably for times when the kit was unable to charge due to bad weather or other circumstances. They were still using between 200-300 HTG for enough charcoal to last about two weeks and 50 HTG for 2-4 days' worth of wood (wood is used for boiling hard foodstuffs such as peas or pasta.)

St. Helene - Ethnographic Profile

P., a St. Helene resident in his late sixties, worked a variety of jobs to support his family. He worked in agriculture, kept animals, and did "construction" (this term, as used by our respondents, encompassed anything from carpentry and woodwork to building furniture). He owned a cell phone and a radio, both of which he charged with his Ti Soley kit. He reported that he would like to have a better battery – one that could last 5-6 days. He had had his kit replaced four times in five months, and still had to walk 10 minutes every day to the solar trailer to charge it. Despite this succession of malfunctioning kits, he said he "felt well" because he had Sirona and other communities did not. When we asked us if having the kit had allowed him to save money or increase his income, he responded that, "We could have more money, but what's really important is that we feel like humans now. Before with the wind there could be problems with the [kerosene] lamp, but with solar that's not an issue."

Leogane - Electrified Village 2

Leogane is one of Haiti's larger towns. At the time of the 2010 earthquake, the population was about 134,000. It is estimated that 20-30,000 individuals in Leogane died during the disaster. Leogane is in close proximity to Port-au-Prince which provides the population with more access to commerce and technology. In Leogane, more people have access to government supplied electricity. Leogane has had the Sirona Sunblazer unit for approximately 2 years so we were able to understand the longer term effects of electrification.

Compared to our previous two locations it was positively urban, although the moment we left the road we found ourselves on dirt roads under the thick foliage of banana tree leaves. Unlike at St. Helene, the solar trailer at Leogane was in a clearing enclosed by bars. Mototaxis and cars zipped through the streets at regular intervals, honking at pedestrians who didn't clear to one side quickly enough. We met our respondents inside the local school building. The school was fenced in, although the front gate was open, and in front of the building was an earthen playground. As we arrived to conduct our interviews, children were still gathered in the yard. While we set up inside, they looked in through the barred windows, laughing and shrieking with their friends.

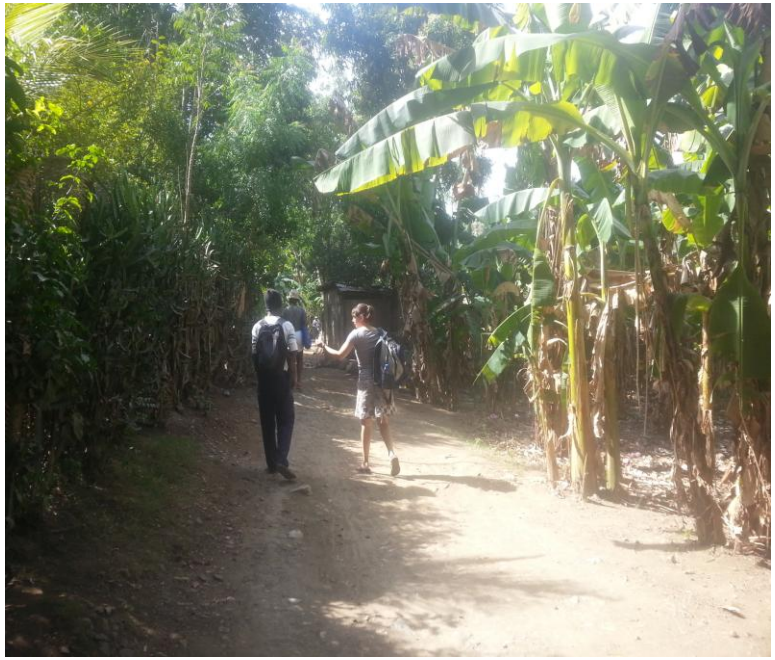
Leogane was the most challenging in terms of interview logistics. We had only one day to interview, and there were at least as many people who showed up to be interviewed as there were at our previous two locations. Because our time there was relatively brief compared to the other two sites, we were not able to establish the same kind of rapport. Still, it was at Leogane that the most important lines of questioning began to cement themselves, and we became aware of more subtle themes in the data, such as the unseen costs of having and maintaining Sirona's services. It also became more apparent through our conversations with Leogane residents the length to which people will go to preserve what electrical energy they possess for high-priority functions like indoor lighting.

As in our Ile a Vache and St. Helene study sites, almost all had a cell phone or access to one through a family member or friend, as well as a radio. However, Leogane had the highest number of respondents who reported having a portable DVD player: out of our 31 respondents, 10 said they owned one. As far as the use of kerosene, customers at Leogane had by far the highest number of malfunctioning batttery kits. Almost 35% reported having to fall back on the gas lamp or candles because their kits were not functioning properly.

At this location, 50% were by small business owners or employed by small businesses, followed by 30% of people were employed in trades and 13% were farmers. Two participants identified themselves as

students. As at the other two locations, a large fraction (30%) had more than one job or source of income.

In Leogane, it was the unseen costs of getting and keeping the Sirona services that drew our attention. Some respondents reported that they paid between 50-100 HTG for a motor taxi to the operator's home. Two of these respondents said they made the trip daily. Others made the trip daily, but on foot.



Even with the reduced functionality of several of the kits, a number of respondents reported positive effects on their quality of life. There were notable differences between the ways the kits were used in Leogane versus how they were used in St. Helene. Several people were not using their kits for cell phone charging so that they could conserve the limited power of the kit for light.

We believe that with more targeted questioning the number of respondents who conserved the power of the kit specifically for lighting will go up, showing the level of priority placed on having light compared to charging cell phones, powering entertainment devices, etc. It is also worth mentioning that a few respondents in St. Helene mentioned that they still paid to charge cell phones (which wouldn't be necessary if they were using Sirona's kits to do so), and one respondent specifically said they split up their usage between the kit and the kerosene lamp so that the kit's power would last longer. This may mean that such conservation behaviors will also become more evident in St. Helene with the same kind of targeted questioning. It will also be possible to draw parallels between the way recipients conserve Sirona power and the way they conserve charcoal, kerosene, and other limited resources. The phrase "if we use it well" was one we encountered often, in all three villages, during our discussions with respondents about their usage of fuels and power.

Leogane – Ethnographic Profile

M. was a Leogane resident in her early thirties. She had four children, three of which were attending public school. She walked 30 minutes on foot every day to charge her unit at the solar trailer. She complained that the battery "is not powerful enough because it can't power a refrigerator." Because she ran her business selling soft drinks out of her home, she had a strong desire to be able to serve cold beverages (a sentiment we heard echoed over and over again at all three locations). She said that electricity made her work more, but it was good for her business because instead of closing her home to customers at 8 or 9 PM, she could sell until 10 or 11. She also said her kids "are more lively because they can relax and study." Although she said was the Haitian government's responsibility to provide her with electricity, she believed herself to be out of their reach where she was.

SECTION 5: OTHER IMPORTANT FINDINGS

Rural Haitians want electricity that is both affordable and reliable. They want to pay a rate that is at or below what they are currently paying for kerosene, for a constant, uninterruptible supply of electricity. They believe that solar energy can provide them with clean, cost-effective, and continuous supply of energy. They also feel that the government should be supplying them with electricity, but has not been able to, so it is their hope that the government will enlist private organizations to assist them in implementing energy solutions for rural villages. Rural Haitians are striving for a better life - electricity has become an aspiration and a sign of doing well.

These thoughts and ideas about solar energy and the government's role in providing energy solutions are discussed in more detail in the next several paragraphs.

5.1 ATTITUDES ON SOLAR ENERGY

We asked rural villagers their thoughts on using the sun or solar energy to create electricity and most people felt that this was a very positive way to produce electricity. Often they mentioned that it was good for the environment, better for their eyes, clothes, and their health. They viewed it as convenient (more accessible) and easier to use than kerosene, and provided much more light. One participant captured it well, stating "The sun is already like a vitamin for our health, the solar energy provides lighting, health, and electricity." They believed that solar energy could make their village more like the city—we believe this meant that they believed their daily life would be more similar to a city like Port-a-Prince and electricity could provide more opportunities for earning a living.

Communities by and large felt that solar was more cost-effective than diesel/kerosene, and in the un-electrified village, they often stated that sun was "free." Their feeling was that it didn't cost anything to use the sun, and it was costing them a significant amount of their monthly income to purchase kerosene and diesel.

They expressed concerns about the ability of solar to provide electricity when it rains and also when it's windy. The rain could impact the solar collector and their ability to recharge their batteries. They expressed concern about finding a balance between the wind and the sun, especially for agriculture. We believe this meant that the wind brought clouds and rain and impacted Sirona's light, but that it also brought rain and perhaps pollination for their crops to grow. It seems they were wrestling with how they could have the benefits of both the sun and wind.

5.2 BELIEFS ABOUT THE ROLE OF GOVERNMENT IN PROVIDING ELECTRICITY

In one of our questions, we asked villagers if they believed the government should supply their electricity. We were trying to understand how communities perceive ideas around self-sufficiency and sustainability when solar energy resources become available and are controlled locally, without reliance on the national grid.

In many ways, Haitians are extremely self-sufficient, with rural communities growing much of their own food, raising animals for food, gathering wood and making charcoal, capturing and storing rainwater, and using kerosene and diesel for lighting and other basic needs. However, kerosene and diesel must be imported, and this is an area where they have little self-sufficiency. Electric light offsets the need for diesel/kerosene but they cannot rely on the government to provide electricity.

Historically, Haitians have had a deep distrust in government and its ability to provide basic services such as electricity, food, and water due to a succession of oppressive and corrupt regimes. Almost unanimously, villagers stated that the government should be supplying electricity, 24X7, but that they could not rely on the government to do so. One stated that "that only a portion are getting it, but all are entitled to it." They said that they have been waiting for the government to provide electricity, that they pay taxes for electricity but only some get access electricity, and not all can afford the government rates.

Our research into this issue showed that the Sirona lighting solution dramatically offset the need for kerosene and diesel. Once people started using Sirona, they were very reluctant to go back to lamps, as the Sirona LED lights were much brighter, did not burn out or emit fuels, and once they paid the $6 per month, they could refill the battery packs as many times as they wanted, essentially providing them access to unlimited lighting for the month. They believed this solution to be much more sustainable and reliable.

Many people felt that they had more control over their electricity with Sirona, and believed that if the government wasn't able to provide electricity, then they should enlist the help of Sirona. They had come to rely greatly on international organizations, non-profits/NGO's and churches for assistance and they seemed to have a strong belief in Sirona's dependability and willingness to provide electricity. The ones who had come from areas where EDH provided electricity stated that they could go for hours or even days without electricity and they didn't know when their lights would come back on.

However, this may have created yet another dependency as many now said they could not live without Sirona. Many expressed that they preferred Sirona over the government-provided electricity—they said the government electricity was so unreliable, it could be out for days, and they never knew when they would have or not have electricity. It seemed that the people were happy to be in control of their own electricity, and since Sirona had been reliable, they were going to be loyal to Sirona. People felt that Sirona was willing to come to their village and supply them with electricity when the government had not done so, and many had been waiting for years.

5.3 IDEAS OF LIVING WELL IN RURAL HAITI

We asked rural Haitians a question about what it means to do well in their society - we believe that this could provide some indications of what it meant to have a good quality of life. Overall, people stated that doing well meant you had consistent access to food and water, and that you have good health and a means to earn a living. Differences were noted by village with Ile a Vache most concerned with basic needs such as food and water, and in fact, being able to eat three times per day was a sign of doing well. In St. Helene, villagers were concerned about having good health and a stable income. In Leogane, people felt that doing well included access to electricity.

The majority of people of Ile a Vache indicated that personally, they were not doing well. One of the women comment that "no one is really doing well, the only people that are well is God, because all are the same here." This sentiment was expressed often and revealed a real concern that they could not meet their basic needs and they had few ways to earn money so they could live better.

In St. Helene, villagers responses were more optimistic and several stated that having electricity had positively enhanced their lives. One person stated that he can send children to school, has a job, can eat 3 times a day and has time for leisure and Sirona helps him to help others - now people come to study at his house and he still feels like he is in PAP because he has electricity. Good health, food and earning a living were still primary indicators of quality of life but we

also heard more responses on having the ability to educate your children and having more time for leisure.

Many respondents in Leogane indicated that having electricity was a sign of doing well. One person stated that people would do well if " if everyone had food and money for electricity." Good health again, was the dominant indicator, along with money to buy what you needed.

Of those who had the Sirona kit, people expressed new consumer purchasing desires - for refrigerators, stoves, TV/DVDs, and irons - these were the most frequently mentioned items if they could have more electricity. They also talked about water pumps for crops and animals, equipment like wood planers to run businesses and many also wanted their own solar panel for their home. A computer was occasionally mentioned but interestingly enough, internet access was not mentioned at all.

Electricity's role in promoting a sense of greater well-being, is an area for continued study.

SECTION 6: LESSONS LEARNED AND OPPORTUNITIES FOR CONTINUED RESEARCH

6.1 LESSONS LEARNED

It is a source of both excitement and consternation to the authors of this project that we have uncovered as many questions as we did answers. Questions that seemed to work well on the page, fell apart in an interview situation and had to be re-tooled, as we had anticipated. Lines of questioning that we thought would be of high importance prior to our arrival gave way to other questions that were more pertinent. For example, we missed opportunities with a single question that, in retrospect, seems obvious now: "What does it cost you in time, taxi fees, or other resources, to get to the location where you can recharge your battery?" Our most complete data on this question was collected at Leogane, and even there we did not ask it nearly as consistently as we should have. We simply failed to realize the importance of the question until after we returned to the U.S. and began mining our data.

Another obstacle we encountered during our interviews was the understandable resistance to questions about average income, income generation, or savings. This reluctance to speak about one's economic resources is cross-cultural and well-documented in the literature, but the sensitivity to economic questions runs especially deep in Haiti, where jealousy of one's neighbors can be a particularly destructive force in poverty-stricken communities. Yet there is no other way to ask it, but to ask it. Our attempts at asking 'around' it with careful phrasing—for example, "How much money are you able to save by using Sirona's services?" or "How can you tell when someone is doing well?"—sometimes produced confusion as respondents tried to figure out what we were really getting at.

Despite some of these unanticipated changes, respondents gave us answers that surprised us and proved to be fruitful in ways we didn't expect. This in turn, provided us with opportunities for continued research and investigation.

6.2 OPPORTUNITIES FOR CONTINUED RESEARCH

Follow up research at these three sites would be beneficial in obtaining more detailed information about some of the questions we raised in this study.

In addition, some other questions for continued research include:

- What are the social and economic impact of different amounts of electricity?
- What community models of off-grid electrification are working and why?
- What are the perceived costs versus true costs of energy?
- Will solar off-grid models of electrification in Haiti, work in other areas of the world?

Access to different amounts of electricity will affect socioeconomic outcomes. In cities, access to grid electricity allowed residents to power appliances like refrigerators, electric stoves, televisions, etc. This helped make cooking easier and allowed people to refrigerate and store food, and view TV shows. In rural communities like St. Helene, only electricity for lighting and small appliances like radio was available. Sirona was not designed to power large appliances, and in its current form remains largely contained to home spaces, requiring light sources like lanterns and flash lights for any activities

taking place beyond the boundaries of the home. These differing amounts of electricity available can result in uneven social and economic development. Perhaps some day off-grid power could rival grid electricity, allowing rural residents to meet or exceed their basic needs and obtain more equal prosperity.

We have already shown how residents expressed a sense of feeling more human once they had solar energy. More research should focus on the deeper meaning of these expressions, and how it progresses as more energy becomes available to a community. It is possible that having light and energy should be thought of as a basic need, like having food, water, and shelter, and that a basic need might be defined as those things which make us feel human.

Local management of resources are becoming more popular with development organizations. In Appendix 1 of this paper, we discuss how scholars of what is called “the commons” can be applied to community management of a natural resource—in this case, solar energy. We believe that evolving a framework for how communities make decisions about who has access to energy resources, how it is maintained, and how it is used, can contribute to more sustainable practices in this area.

In looking at energy cost models, we see they do not often take into account some of the unseen costs of harnessing energy, including travel time to an energy source, or lost productivity as a result of time spent gathering energy. Providers may not be aware of additional costs to consumers that are unaccounted for in business models, and consumers may perceive costs of a service as high, even if the cost is the same or less than that of other fuels. Consumers often do not take into account the cost of productivity lost as a result of not having an energy source. True energy cost models must look at all facets of daily life to better understand economic effects on consumers.

Lastly, with the global push for electrification of impoverished communities, some key questions emerging are will solar electrification models in Haiti, work for South Africa? What happens when a model initially developed under particular local conditions in Haiti, becomes widely emulated? The context then becomes very important. What are the environmental challenges in the country? What policies are being enacted by government? What transnational organizations are involved in this process and why? It is important to understand the political forces that are shaping the rhetoric and enacting the processes.

We believe that the human dimensions of energy use are often neglected in social science research. We echo the thoughts of anthropologist Tanja Winthers when she says "Perhaps this is due to energy’s invisibility – its doxic, taken-for-granted flow as mysterious to most people as its effects are profound and ubiquitous. Uneven social, political, economic, and environmental impacts simultaneously accompany these flows in a global circuitry of energy and trade that is as cultural as it is physical, bringing different, intersecting forms of power into perspective." We believe there are ample opportunities for continued research with respect to understanding human behaviors in the context of sustainable energy use.

APPENDICES

1 - Theoretical Framework

2 - References

3 - Original Protocol and Revised Protocol

APPENDIX 1

Theoretical Frameworks of Rural Electrification Projects

Poverty reduction and improvements in the quality of life among the rural population is the implicit goal and justification for electrification. Electricity access is already well established within the framework of human rights, either implicitly as part of sustainable development or explicitly in the context of eliminating discrimination against women.

In looking at previous studies, including the rural electrification in places such as India and regions such as Africa, and even at historical periods such as that 1930's initiatives in the United States, we can see a multitude of dramatic and positive changes resulting from electrification. Tanja Winther's study on a village in Lesotho shows a range of both direct and indirect changes from electricity which improve the quality of life in the villages. We find a multitude of positive effects in core indicators such as health, economics, well-being, education. However, very little attention has been paid to the underlying dimensions of electrification such as political economy, consumerism, gender relations, rhythm/speed of life changes, and effects on sexuality, rituals and spirituality. A survey cited by the World Bank found that while electricity is an integral component of development strategy, it alone will not lead to poverty alleviation, except in that it may provide jobs directly related to the industry. They advocate for a range of development initiatives along with a Rural Electrification Program as an important way electrification can successfully contribute to raising a community's standard of living.

In spite of the positive dimensions of electrification, new dilemmas are emerging in these other areas.

It is possible to say that the idea of a longer day, unlimited by the dark, is a Western ideal. It is equally reasonable to suggest that humans, as diurnal creatures, have always striven toward light. In "Brilliant: The Evolution of Artificial Light," Brox traces the history of human attempts to break outside of the confines of darkness - to remove the bookends of dawn and dusk. These efforts go back as far as Babylonian times and are cross-cultural. Our goal is not to say which story is true; rather, we are reporting the desires of the rural residents we interacted with, regardless of how those desires originated.

The pros and cons of artificial light are relative over time. For example, in a recent segment on National Public Radio, David Kestenbaum explained that when kerosene appeared on the world stage at the beginning of the 19th century, it was praised for its cleaner, brighter, longer-burning flame (NPR May 2014). For many, the creation of kerosene was a dream come true. Today the same substance, which was once considered a miracle oil, is reviled for its malodorous, inefficient, and polluting effects.

Khandker, Barnes, and Samad point out the importance of determining whether or not a rural electrification technology is more beneficial to higher income families than to the poorest members of a community. They ask, "Do higher-income households adopt electricity, or does electricity lead to higher household incomes and improved rural livelihoods?" More broadly, they are highlighting the question of causality – to what extent can developments that appear

connected to the presence of a rural electrification project be directly attributed to that project? (Khandker, Barnes, and Samad 660). In their case study of Vietnam in the early 2000's, their conclusion was that access to electricity (in this case, grid electricity) was strongly linked with completion of higher levels of schooling, especially among girls; that households with a grid connection were much more likely to engage in home-based enterprises than those without electricity; and that the availability of electricity was related to rising incomes among households, although the percentage increase depended on whether electricity was available at the commune level or the individual household level.

According to Quoilin and Orosz (2013), the high failure rate among decentralized power generation projects is related to lack of planning regarding local institutions, socio-economic environment, and hierarchical links between local actors (200). They name eight factors that they believe help to create successful power generation projects: 1) participation of the target population, 2) technology adoption/installation of a demonstration plant, followed by a diffusion phase, 3) "appropriate" technology, 4) cost, 5) technology transfer and maintenance, 6) decentralization, 7) environmental impact, 8) energy needs and demand, 9) technology deployment strategies, and 10) subsidies.

Research on community management of infinite energy resources such as solar sunlight, in the context of a development framework, has been scattered and insufficient. Past research is heavily focused on state and utility management of oil and gas resources, and not on local management of natural, infinite resources such as solar and wind. With the recent global push towards poverty alleviation in developing countries, and the expansion of middle class, the demand for electricity has outpaced supply. With electric grid expansion too costly, off-grid solar and wind systems and micro-grid systems that can be community managed and owned, are rapidly filling the gap.

New models of community management of these resources are desperately needed as these systems are being deployed at a dramatic pace, spurred by development funding from multi-lateral organizations. Many organizations have documented effective community management of resources, eschewing the notion that local populations cannot manage their own resources and need outside assistance from NGO's, the governments, or other nations. These organizations are in fact, driving a global movement to put the power in the hands of the people through funding of renewable projects. Brosius states that "community-based natural resource management programs are based on the premises that local populations have a greater interest in the sustainable use of resources than does the state or distant corporate managers; that local communities are more cognizant of the intricacies of local ecological processes and practices; and that they are more able to effectively manage those resources through local or "traditional" forms of access." This model may well apply in the context of management of solar sunlight to produce electricity – communities understand their basic energy needs, the limits of their current environment, and the daily practices that can be more effectively enacted through sustainable energy supplies.

In Haiti, a lack of electricity has induced environmental degradation as forests and other plant and animal habitats have been used to supply woody biomass for daily chores such as cooking. Links between environmental degradation and social inequity have been articulated in previous research. In looking at who receives electricity, we can see that the more wealthy urban centers are the first to receive energy, and those rural locations, far removed from the larger cities, are usually last on the state and utility agenda.

Therefore, rural peoples tend to use whatever environmental resources they have in order survive. However, in the case of electrification, there needs to be a realization that goals of conservation and effective resource management go hand in hand with helping marginalized populations receive electricity. Shifting communities to renewable sources such as solar sunlight eases the pressure on local forests to supply for their basic needs.

As Brosius states however, the spread of community management practices can also raise "challenges and dilemmas as concepts of community, territory, locality, conservation, and customary law are worked into politically varied plans and programs in disparate sites."

One of the themes emerging in community solar is the idea of community ownership of the resource. The initial rollout of the Sirona Sunblazer unit was funded by the United Nations and U.S. Agency for International Development. Since limited funding is available, a new model of ownership has been developed whereby a village operator owns/leases the unit to resell the electricity to the villagers. The success of this model is yet to be seen but some of the issues that could arise around this include: Who really controls the solar resource? Does it create power inequities within the community? How does the selection process work - who can be an operator and what village will receive a unit? As Brosius believes, we need to look at "the regional and local processes of expropriation, reallocation, and management in which political and economic inequalities are established and reinforced."

We would be remiss if I didn't bring up Hardin and Feeny's discussion on the "tragedy of the commons" and how it might apply to community management of a solar resource. Hardin assumed that all people are rational self-maximizers. So therefore, can solar electricity, which is a free and unlimited resource, be used sustainably by the community? In this context, the sun which powers the Sunblazer unit is free, and thus far, the unit has been provided by an international organization however, the battery pack are not free - Villagers need to purchase these. Is the unit considered a community resource? Anecdotal evidence from Sirona suggests that these units are considered communal property since the village is taking care of them and protecting them. There have not been any cases of theft or vandalism of the units in the 2 years they have been in the villages. Other villages have not been given access to the units, therefore, the units, and the solar resource, cannot be considered open access and have what Feeny calls "excludability." In this case, rights to entry and use have been allocated, which is a condition for successful management of the commons. However, if certain villages become electrified, and others do not, will there be a demand for resource sharing from the unelectrified villages? Feeny calls this "subtractibility" or each user being capable of subtracting from the welfare of other users. Will the electrified villagers begin to sell the electricity to other villagers and thereby perhaps deplete the units? Who has first access when the sun is not shining for a long period of time? Under normal conditions of sun during daylight hours, the units can continue to operate as there is a backup battery that lasts for several days and is replenished by the sun daily. However, during times of little or no sun, the battery may become depleted and therefore the villagers may have to go without electricity.

Even in the situation of an infinite resource such as sun energy, theories on management of natural environmental resources offers lessons that we can draw upon and apply.

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APPENDIX 3- ORIGINAL AND REVISED PROTOCOL

Original Protocol

Interview Protocol for Haiti

Participant Name/ID:_____ Interviewer Name/ID: _____

(A pseudonym will be used if you ask us not to take your name.)

Interview Date: _____ Start Time: _____

Age/DOB:

Home Village:

Gender:

Part 1: Introduction

Hello, and thank you for agreeing to participate today. My name is Laura/Amanda/Fabienne and we are working with Sirona Haiti. We're conducting these interviews to learn about the role electricity has in people's lives, and to provide Sirona with suggestions for how to provide the best service possible to its customers. I will be asking you a series of questions about your daily life and access to electricity. There are no right or wrong answers here - I am interested in what you think. The interview should take approximately 45 minutes.

Part 2: Consent (VERBAL)

I will be taking notes on our conversation so I can remember what we discussed. I'd also like to record our discussion, if you don't mind. It will help in two ways. First, I won't have to focus so much on taking notes as we go. Second, it will allow me to listen to it again later to make sure that what I think I understood is what you really were saying. I [and our research team] will be on the only person [people] who would hear what you

say. It will never get back to anyone you know. We will take your name out of anything we write or present about this work. You do not have to answer any questions that make you uncomfortable. Please feel free to ask me any questions you may have.

Part 3: Semi Structured Interview

The goal of this interview is to understand what needs Sirona can meet with its solar power service. In order to do this, we have to understand what life is like here currently without/with regular access to electricity.

5-7 General Questions for all Participants

Q1: Take me through a typical day for you.

- How does it start? What's next?
- What are the most important things you do?
- How do you think that is different for people with/without electricity?

Q2: What do you do for lighting, warmth, cooking in your home now?

- Do you use any electrical devices?
- Where do you get kerosene, batteries, wood and charge your phone?
- How much time does that take you? How often do you go?
- How much do you pay for fuel, wood, cell phone charging per month? How much fuel, wood does that allow you to get, how many cell phone minutes?
- Which family member does the trip?
- How do you get there?

(Electrified Only) Do you make dedicated battery trips or do they combine this with other needs - e.g. market visits? Are you near a Sunblazer - is so, How far you from the Sunblazer in terms of travel time?

Q3: Tell me about your work or how you make money?

- What are your main sources of income?

- Do you believe having electricity will/does affect your work? If so, how?
- How do get what you want or need - do you barter or trade?
- What have you purchased anything recently? Can you tell me what you purchased in the last month, last year?

Q4: What do you do to relax when you're not doing your work?

- How much time do you have for leisure each day?
- day and night time?
- How has electricity changed your life?
- What makes life good or better here?
- How can you tell someone is doing well?

Q5: What do you think of sun powered electricity?

- Has it changed your daily life? How so?
- Do you gather and burn as much wood as you did before electricity?
- Do you believe the government should supply your electricity?

Q6: Do you have any children? (Optional)

- How many of them are school age?
- Of those who are school age, how many are able to attend school this year? Next year?
- What will/has changed for your children with respect to daily activities, what will/do they do more or less of?

Part 4: Debrief

I have a couple of additional question for you that I missed. (ask) Is there anything else you would like to share with me? Is there anything you found sensitive or uncomfortable? Would you like to know the results of my research?
Thank you so much for your time.

Revised Protocol

Interview Protocol for Haiti

Participant Name/ID:_____ Interviewer Name/ID: _____

(A pseudonym will be used if you ask us not to take your name.)

Interview Date: _____ Start Time: _____

Age/DOB:

Home Village:

Gender:

Occupation:

Part 1: Introduction

Hello, and thank you for agreeing to participate today. My name is Laura/Amanda/Fabienne and we are working with Sirona Haiti. We're conducting these interviews to learn about the role electricity has in people's lives, and to provide Sirona with suggestions for how to provide the best service possible to its customers. I will be asking you a series of questions about your daily life and access to electricity. There are no right or wrong answers here - I am interested in what you think. The interview should take approximately 45 minutes.

Part 2: Consent (VERBAL)

I will be taking notes on our conversation so I can remember what we discussed. I'd also like to record our discussion, if you don't mind. It will help in two ways. First, I won't have to focus so much on taking notes as we go. Second, it will allow me to listen to it again later to make sure that what I think I understood is what you really were saying. I [and our research team] will be on the only person [people] who would hear what you say. It will never get back to anyone you know. We will take your name out of anything we write or present about this work. You do not have to answer any questions that make you uncomfortable. Please feel free to ask me any questions you may have.

Part 3: Semi Structured Interview

The goal of this interview is to understand what needs Sirona can meet with its solar power service. In order to do this, we have to understand what life is like here currently without/with regular access to electricity.

5-7 General Questions for all Participants

Q1: What activities do you do during the day? During the night?

(For electrified village only) How has having electricity changed that?

Q2: What do you do for lighting, warmth, cooking in your home now?

- What electrical devices do you use?
- Where do you get kerosene, batteries, wood and charge your phone?
- How much time does that take you? How often do you go?
- How much do you pay for fuel, wood, cell phone charging per month? How much fuel and wood do you use per month and how many cell phone minutes?
- Which family member does the trip?
- How do you get there? Does it cost you anything to travel to get fuel, wood or charge your phone?

(Electrified Only) How far you from the Sunblazer in terms of travel time? Does it cost you to travel to a Sunblazer to refill your Ty Soley?

Q3: What have you purchased recently? Can you tell me what you purchased in the last month?

Q4: What do you do to relax when you're not doing your work?

- How much leisure do you have per day?

- Has having electricity changed this? (electrified only)
- What time do you go to bed?

Q5: What makes life good or better here?

- How can you tell someone is doing well? Do you feel like you are doing well?

Q5: What do you think of sun powered electricity?

- Has it changed your daily life? How so?
- Do you believe the government should supply your electricity?
- If you could wish for more electricity, what would it be used for?

Q6: Do you have any children?

- What will/has changed for your children with respect to daily activities, what will/do they do more or less of?

Part 4: Debrief

I have a couple of additional question for you that I missed. (ask) Is there anything else you would like to share with me? Is there anything you found sensitive or uncomfortable? Would you like to know the results of my research?
Thank you so much for your time.