Social Entrepreneurship and the Solar Revolution

Kirsten Petersen
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Background:

In-country technical support systems are necessary to fulfill the potential of solar photovoltaic technology to eradicate energy poverty in rural Uganda. Before I describe why, let me explain how I got to the point of drawing such a conclusion.

During my sophomore year, We Care Solar ran a workshop at Santa Clara University. This two day crash course on stand-alone energy for the developing world, specifically the Solar Suitcase, brought to light the *engineering with a mission* mantra emphasized at our School of Engineering. Hal Aronson and Mike Strykovski taught roughly ten students to assemble and wire Solar Suitcases, suitcase-sized solar modules with LED lamps and power supplies designed bring power to aid midwives in northern Nigerian maternal health clinics. Without access to electricity these rural clinics would have to do operations and assist in births by kerosene lamp. In my world of ever-accessible centralized energy, this choice to go for distributed energy systems instead of grid extension was novel – and marked the beginning of my relationship with off-grid energy solutions.[1]

Solar Sister:

The following summer I experienced the Global Social Benefit Incubator (GSBI) 2012. The Solar Sister business plan presentation by CEO Katherine Lucey made a lasting presentation – what is not to love about integrating solar, women, and social development!

Figure 1: A Solar Sister in Masaka, Uganda

[1] We Care Solar http://wecaresolar.org/

Sister seeks to eradicate energy poverty for the 590 million people in Sub-Saharan Africa who live without access to electricity. They do so through an Avon-style network of 177 women entrepreneurs who bring "light, hope, and opportunity" to Uganda through the distribution of portable solar-powered lighting. These entrepreneurs are part of a "last-mile" solar product distribution system which is deliberately women-centered because women are the primary managers of household energy use and purchase in sub-Saharan Africa -This provides economic opportunity for these women, which significantly contributes to gender equality.[2] Each solar sister is equipped with a "Business in a Bag" containing about ten different solar products to be sold in her respective community. By selling multiple brands Solar Sister is not significantly impacted if one particular brand loses stock. Their products are chosen based on in-country market research as well as by referencing the Lighting Africa reports. When compared with kerosene all solar products are superior, but when compared with each other there is definitely a hierarchy of products.

Figure 2: A Collection of Portable Solar Lanterns at the Solar Sister office in Kampala, Uganda

In high school I found my love of renewable energy as a member of the Physettes, a club I helped to establish at my high school for girls interested in science, math, and engineering. Once I got to college I found my place in the Society of Women engineers and my excitement for pursuing a career in engineering grew. Seeing parallels between these groups and Solar Sister I felt a connection watching the GSBI presentation. These women-centered networks couple the advancement of sustainable technologies with the support and resources to enable women to advance in gender-biased situations. All have influenced me in the pursuit of attaining the technical skills, in-country experience, and strategies to make solar energy sustainable and affordable in emerging markets.

Global Social Benefit Fellowship

You can imagine my excitement when I realized there was an opportunity to spend a summer with Solar as a Global Social Benefit Fellow. I could combine my technical studies in electrical engineering with my passions for renewable energy solutions and women empowerment. In a

[2] Solar Sister http://solarsister.org

multi-disciplinary team, my Solar Sisters Misa Mascovich and Victoria Yundt, along with seven other students I spent one quarter in a crash course on social entrepreneurship, studying business plans and case studies on existing social enterprises.

The next step was a six week internship in Uganda with Solar Sister. When I left for Uganda I was equipped with background information on product development for the developing world from interviews with Barefoot Power, Nokero, and Angaza Design and the intention of finding out what is working and what is not with solar in Uganda. The main deliverable for the Solar Sister Internship was a series of three videos – one promotional, one for donors, and one as a conversation-starter for Solar Sister training sessions. As a result, much of our time was spent traveling to customers, Solar Sisters, and community members to conduct interviews on opinions and experiences with solar – this meant talking to a lot of people. Through this vehicle, valuable qualitative feedback was given and the remainder of this document will outline the views.

Solar Products

Phone Charging

Typically, the products that incorporate phone charging are more popular than the lighting systems without this capability. Especially if prices are equivalent, the phone charging capability is always chosen over strictly lighting. This is primarily because of the huge poverty premium implicit in mobile phone usage without personal access to electricity. Alternatives become charging your phone at a local business or using a phone charger at a neighbor's home – all more costly than charging yourself.

Figure 3: Phone Charging from a Solar Portable Lantern

There are two standard topologies for solar portable lanterns and systems with mobile phone charging capabilities. The first model charges phones directly off of the PV panel. Barefoot Power's Firefly Mobile is an example of this typology. Because batteries are the most expensive component of PV systems, this model is appealing for affordability reasons. The system can afford to have a smaller battery because the power needs of mobile phones is covered by the

panel output with no reliance on the battery. PV power is intermittent, however, and it is characteristic of batteries to want a steady input. Fluctuations in current result from changing panel conditions –shading, temperature, etc – and these spikes can damage the phone's battery if not properly controlled. Charging can also only take place during daylight hours which can pose a problem if the most convenient time for the end user to charge their phone is during the night time.

The second model is to allow for phone charging off of the internal battery of the lantern. This model includes products like the Greenlight Planet SunKing Pro and d.Light S250. By charging off of the internal battery it is possible to charge cellphones at any time, day or night. However, this requires the battery to be able to handle both lighting and the charging as loads, and therefore must be larger than the off-the-panel alternatives. Charging the phone also depletes the capacity available for lighting which means shorter time lights can be on. If the battery is completely depleted it is also an issue that it may take more than one day to fully charge again, especially if sun conditions are not ideal.

Figure 4: Greenlight Planet's Sun King Pro

One additional issue with phone charging is that these systems only work with standard phones available in Africa. Some imported phones do not fall into this "standard" category, however, and if someone has already purchased a phone, they will not be able to use the portable solar products.

The Problem with "Made in China"

Poorly manufactured lighting products from China have flooded the solar market in Uganda. Such products often have short lifetimes, are unreliable, and are not as durable as products living up to the standards of Solar Sister. This causes the customer to lost faith in the viability of solar in Uganda. As a result, there is a major distrust amongst Ugandans of all solar products from China. In interviews with Solar Sisters it was found that many potential customers will not even consider making a purchase once it is discovered that the products are from China. To combat this problem the Solar Sister entrepreneurs are strongly emphasizing that their products are "designed in the USA" or "designed in Australia," depending on the product, and they are all manufactured at high quality factories in China with standards of quality control. This conveys

quality, as does Solar Sisters own market research and reliance on the reports of Lighting Africa.[3]

Figure 5: These lighting products sold roadside in Gulu, Uganda

International Social Enterprises like Barefoot Power and d.Light rely on manufacturing in China because their business models would not be sustainable if manufacturing took place on a local level – the high cost associated with local labor and it is difficult to ensure uniformity in manufacturing facilities or even the availability of the necessary heavy machinery for their respective products.

Some enterprises, however, have centered their purpose on local manufacturing and building technical capacity at the village level. Grameen Shakti, for example, has created a one-stop solar service business to Bangladesh. Finance, manufacturing, installation, maintenance, repair and training all take place at the local-level. By keeping the wealth in the village, business does well if the village does well. Mohammed Yunus believes that you have to produce locally to be sustainable for a multitude of reasons including that it simplifies logistics, cuts importation costs, allows for on-site servicing, and enables growth at the village scale. [4]

Product Appearance

Solar Sister entrepreneurs reported that several customers have provided feedback on the appearance of portable solar lanterns on the market. If you look through the arsenal of available products there is a general trend toward bright, bold, rounded products – products that look as durable as they are – similar to the rugged camping lights you might find at a REI. Some customers have reported that this makes the products look like toys. This is a problem in that regardless of culture, there is a desire to have one's home look nice. As lights are the brightest installments in a home and centrally located, appearance is not a trivial design consideration. Products should display a level of elegance while still maintaining a rugged quality. This is definitely a balancing act because ruggedness is so important, but it is also worth analyzing if it really needs the capability to be run over by a car, as is emphasized with d.Light's products.

[3] Lighting Africa lightingafrica.org
[4] Nancy Wimmer, Energy for a Billion Poor

When asked if customers would prefer a product that looks mass produced and of western origin or a more home-made look with local design elements, the majority leans toward the mass produced look. Additionally, white light LEDs are preferred over the more warm yellow light. This is an issue to consider if the option of in-country manufacturing is viable – how do you make something designed in a village look uniform and professional?

Figure 6: Solar Products made by students at the Nsamizi Institute for Social Development in Mpigi, Uganda.

Another interesting point we discovered at Barefoot Uganda is that the larger and heavier a product is, the more expensive it seems to customers. Though size does not always correlate with price, it is important in designing to consider that the market might not necessarily want increasingly small products. For example, two PV panels of identical wattage can be vastly different in size depending in the efficiency of each. This goes to show how much of product design is in perception.

Applications

Everyone we interviewed when asked what they wish their solar product could power said a television. TVs open the door to entertainment, educational programming, and a window into international communications. When designing a solar product, however, it is important to ask if there is a market for it. New products need to be designed for areas where there is a demand and at this point televisions may be more of aspirational purchases. Several years back mobile phones were considered aspirational purchases, however, so it is possible that one day the solar market will have widespread systems that can power televisions.

Uganda is leapfrogging the United States in several areas– with Solar Sister's focus on distributed power, increased adoption may prove an electrical grid obsolete. The same concept applies to mobile phones over landlines and laptops over desktop computers. There is no reason why the same cannot happen with appliances. With the advancements in smart phone technology there is a possibility that several appliances will be obsolete all together if one invests in a smart phone. This involves unconventional thinking in analyzing need in the context of a western perspective.

After Sales Servicing

One afternoon Misa, Tori, and I were walking with a Solar Sister named Florence and we asked what seems to be missing in the distribution system for portable solar lanterns. Simply put the missing piece was the skillsets to troubleshoot. Florence told us that sometimes people come to her with products that do not work and she would like the ability to find what is not working. Sometimes the problem stems from user error, sometimes it is a dead battery, sometimes a lose connection, and occasionally the products is broken beyond repair.

One option is to send the product back to Kampala to be serviced or replaced. This is a time consuming process which involves the product having to be passed between many hands – from customer to Solar Sister entrepreneur to regional coordinator to the central Kampala office. Another option is to train the Solar Sisters themselves to be solar technicians. There are already trainings in place to teach the necessary skills for the sales representative to do services on the specific products that Solar Sister sells. This has been proven successful by Barefoot Power with their village technicians who are obligated to remain responsible for servicing of the customers they sell to. We Care Solar, as another example, puts their distributers through a course in installing and maintaining their solar suitcases.

Trainings for After-Sales Servicing would work best if based off of and responding to encountered issues. The most common issues are improper use, bad batteries, dust in the system, and bugs eating the internal wiring. At one of the second trainings the three of us attended one Solar Sister entrepreneur told us that many of her customers want to or try to open up the products themselves if there is a problem. This is risky if the end user has no previous electrical experience, but without being provided a concrete method for tapping into a support system, what other option do they have?

After-sales servicing can also be difficult because all of the solar products available for purchase in Uganda are manufactured using surface-mount technology – technology which cannot be services with a simple soldering iron. In order to be serviced a product would ideally be through-hole.

Training Sessions

Currently the women of Solar Sister elect to attend monthly training sessions run by a regional coordinator. Topics at these sessions range from technical topics to business and sales skills. From my experiences in the Latimer Energy Lab, teaching solar technologies to people without a technical background easily linked to a presentation at a monthly training session for the Solar Sisters.

Figure 7: Zaina and Mary Lead a Training Session in Masaka, Uganda

I learned that solar is primarily taught through analogy. The one employed by Solar Sister is the comparison of the sun, panel, and battery to rain, gutters, and a water basin. Both harness natural resources, store it, and you are left with a certain capacity to use. All of the products present in the Solar Sisters' "Business in a Bag" are explained and to ensure understanding, each trainee is asked to stand up in front and explain one of the products back to the solar sisters.

These sessions are also a venue for learning best practices or finding solutions to problems - topics range from problems of people not realizing the panel and light have to be connected in order for charging to occur to strategies for panel placement. For products with separate panels and lights, panels are often placed at the back of the house for security reasons. This is not necessarily the optimal side for maximum sun, however. Because of Uganda's proximity to the Equator, teaching the theory behind angle placement is also important. There are also many myths associate with solar that the Solar Sisters have experiences. One such myth is that the presence of solar products attracts lightning storms to the area. By increasing the solar education training through the solar sister entrepreneurs to the customers, solar adoption will increase.

Figure 8: A Solar Sister explains the d.Light Kiran Lantern

Affordability is one of the most pressing issues of widespread solar adoption in Uganda so it is a necessary topic for training because it will most definitely affect the customer. Accessibility comes through innovative financing options and this is possible through Solar Sister's Last-Mile distribution model. The clearest way to show affordability is through personalized energy audits and long-term cost analyses for the customers – weekly cost of kerosene, cost of transportation to get to it. After doing this, the payback period of solar products can be successfully shown – sometimes as soon as one month.

Senior Design and Roelandt's Grant

Through interviews with customers and Solar Sisters it was clear that troubleshooting, repair, and battery replacement of solar products was a necessity and frequently a mission component in the distribution chain. If a products stops working it does not bode well for the widespread adoption of solar. A product may be affordable, rugged, and useable, but it is of little use if there is no way to service it, especially for easy fixes like battery replacements. Failed systems can remain unserviced and this stimulates market spoilage.

To combat the issue of failed solar systems and increase technical capacity on a local-scale, the Nsamizi Training Institute for Social Development, one of the oldest in-service Government Training Institutions in Uganda, contains a certificate course in solar technology which covers basic engineering design, manufacturing, installation, and repair of solar home systems and lanterns. At the end of the internship I met Nsamizi students and was able to spend the day in their solar lab. The lab fosters community-centric involvement in eradicating energy poverty, focusing on developing human capacity in the form of transferrable skills attained from learning manufacturing, installation, and servicing of solar energy products.

Figure 9: Students assembling solar charge controllers

Upon learning of this Solar Technology Lab, Tori, Misa, and I mutually saw the potential for collaborations between such a lab and Solar Sister. These students are within the communities and have the technical background in solar manufacturing to be able to understand and service products sold by Solar Sister. This meeting was not the last interactions we would have with the solar technology lab at Nsamizi.

Four graduates of this program have started a Community Based Organization, Energy Made in Uganda, to continue the trainings at Technology Centers and locally manufacture Solar Home Systems to be sold in Ugandan communities, with the mission to ensure these systems are locally servicable. Currently Solar Portable Lanterns are the most easily disseminated solar solutions but once there is access to lighting and charging there opens the possibility for growing energy demand. This can be addressed through home-scale solar systems. In partnership with these four students, I am currently completing a senior design project, made possible by the School of Engineering and a Willem and Maria Roelandts Fellowship, to optimize the electronic design of a Solar Home System in terms of efficiency, affordability, safety, serviceability, and meeting the customers' needs. The system takes advantage of day night switching, running off the panel during the day and off of the panel during the night, to optimize the best of both charging topologies. In addition it is deliberately designed using through-hole technology to allow for in-country maintenance. The students we are partnered with are currently working on designing the system box and lighting features to look as mass-produced as possible because of expressed interest by the customers of steering toward mass-produced looking products rather than local looking.

I hope for this to serve as a venue for students involved with the Center for Science, Technology, and Society to gain exposure to socially-minded projects, learn valuable lessons on engineering in the developing world, and continue this focus on *engineering with a mission.* I deliberately chose to continue the fifth year at Santa Clara University because the unfolding of my vocation feels to be at a crucial point. Webs are being formed and I do not feel like my work here will be done in two quarters. It excites me to see how passionate the School of Engineering is toward incorporating projects and partnerships with the developing world and I anticipate this to be only the beginning. From here I want to take the experiences of the fellowship and be involved in our country's energy sector or in semiconductor development in Silicon Valley, strategically looking for corporations with outstanding Corporate Social Responsibility programs - particularly if they are involved with support of social enterprises, improving the quality of life for those they serve.

Figure 10: A solar lighting installation in progress