Evaluating 'Business Opportunities with Solar Energy in Un-electrified Areas' in Namibia

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Date: May 6, 2010

Evaluating 'Business Opportunities with Solar Energy in Un-Electrified Areas' in Namibia

An Interactive Qualifying Project
submitted to the faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
degree of Bachelor of Science

Sponsoring Agency: Desert Research Foundation of Namibia

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Report Submitted to:

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Executive Summary

Over 60% of Namibia's population does not have access to grid electricity. There is enormous pressure on government agencies such as the Ministry of Mines and Energy to rectify this problem as the lack of electricity is hindering the country's economic and societal growth. The government's 'Regional Energy Distribution Master Plan' (REDMP) will connect a large number of rural settlements to Namibia's main distribution grid over the next 20 years, but it is not economically feasible or technically possible to electrify all off-grid settlements. For those settlements that will remain un-electrified, there is the 'Off-Grid Energisation Master Plan' (OGEMP).

The OGEMP proposes installing solar powered energy shops in rural, un-electrified areas throughout the country. Such energy shops would provide basic energy services such as cell phone charging and haircutting, and sell energy products such as paraffin gas, candles, and eventually solar panel systems. Although the OGEMP was slated to begin in 2009, as of April 2010 the government has yet to install any energy shops in Namibia.

In mid 2009, a non-government organization, the Desert Research Foundation of Namibia (DRFN), launched a program entitled 'Business Opportunities with Solar Energy in Un-Electrified Areas'. This program closely resembles the energy shop idea detailed in the OGEMP; however, the two programs are independent of each other. The DRFN hopes to use its program as a model in order to test certain aspects of the OGEMP. By October of 2009, ten energy shops were installed under the DRFN plan.

We, a team of students from Worcester Polytechnic Institute, were asked to initially assess the success of this program and make recommendations for improvement. Our assessment included factors such as economic success, social implications, technical capacity, and customer satisfaction. Data analysis, entrepreneur interviews, community member surveys, and first hand observations allowed us to determine each shop's performance in those areas.

Prior to our field work, financial records from the ten shops were sorted and analyzed to the fullest extent possible. Knowledge gained from these records allowed us to complete a preliminary profile of each shop and its entrepreneur. These records also guided us when devising specific questions to ask during our visits to each energy shop. In conjunction with this, we developed overall questionnaires for entrepreneurs and

surrounding community members as well as criteria for an area evaluation. Communication with our DRFN sponsor, Robert Schultz, and project liaisons, Abraham Hangula and Jimmy Itamba, allowed us to further refine the entrepreneur interview questions, the community member surveys, and the area evaluation criteria. We then visited two energy shops located just outside of Windhoek to test our surveys and interview questions and refined them to more effectively conduct our subsequent field work.

The remaining eight shops were visited in a single trip spread over a ten-day period. At each shop, we interviewed the shop entrepreneur, surveyed between five and ten community members, and evaluated the shop and its surrounding area. Since each shop differed greatly in layout, activities, and entrepreneurial activity, we were able to collect a wide range of entrepreneur and customer responses regarding the energy shops.

Upon our return to the DRFN, we began compiling and organizing our collected field data. The entrepreneur interview responses, community member surveys, and area evaluations were all transcribed into spreadsheet format for easy comparison and data analysis. Different aspects of our data were combined to generate graphs from which conclusions can be drawn. Final entrepreneur profiles were developed that succinctly describe each shop.

Conclusions

We concluded that the energy shops on an individual basis were economically viable, where economic viability is defined as the ability to pay back the solar system with interest in five years or less.

We also concluded that the social implications of the energy shops were overall positive due to the fact that they provide employment opportunities while delivering a needed service to rural communities.

Moreover, we concluded that the energy shop concept is feasible on a larger scale, due to the 75% satisfactory economic performance, rating by customers, and the potential for a rolling implementation plan.

Recommendations

The following details recommendations we have developed to improve the DRFN pilot program. These recommendations should be useful to the DRFN as well as the Ministry of Mines and Energy in their future off-grid energy endeavors.

We recommend that entrepreneurs be required to distribute EPOGES (energy profiling survey) to their community as part of the application process.

The completion of this market assessment survey will determine if energy shop services can be useful in a potential area while also showing the perspective entrepreneurs' interest level and dedication to the reception of a solar system. If the entrepreneur actively distributes the survey and returns the results to the DRFN, it is likely they will operate their shop with similar efficiency. Conversely, it is unlikely that someone who does not distribute the survey and return the results to the DRFN will adhere to certain contract requirements, such as reporting monthly financial income. Additionally, results of the survey can be used to determine if there is in fact a need for an energy shop in a particular community.

We recommend choosing entrepreneurs that have received prior business education.

Analysis of the financial records revealed that entrepreneurs who had previous business education performed significantly better than those entrepreneurs who did not. For this reason, entrepreneur selection should focus on individuals who have attended at least some formal classes regarding business and/or management practices.

We recommend that preference be given to those shops located farthest from the closest grid connection.

The financial records showed that shop revenue increased with distance from the closest grid connection. Competition arises when a settlement is located too close to a grid connection. Shops placed in remote locations will have a larger regular customer base than those shops in peri-urban areas, resulting in greater revenue generation.

We recommend that attendance to the system training at the DRFN be mandatory for all entrepreneurs.

Three of the ten entrepreneurs did not attend the system training in 2009. One entrepreneur sent a substitute in her place and the two others received the system late.

These three were not as educated in system operations and record keeping as the rest of the entrepreneurs. This led to a few misunderstandings regarding financial record keeping and understanding system capabilities, lowering their revenue. This problem could be rectified through mandatory attendance.

We recommend that the training include the technical aspects of the solar system.

Knowledge of technical specifics would aid the entrepreneur in day-to-day operation of the solar system. The entrepreneur should be aware that the solar panel is 80 watts and that the standard 12-volt battery has a storage capacity of 105 ampere hours (Ah). As a result, it will take approximately 16 hours to fully charge the battery to its maximum energy level of 1260 Wh. However, the batteries provided with the solar system should only be discharged by 80% of their maximum energy or they will be damaged. Adding up the watt ratings of similar appliances to be charged and dividing the total by the maximum battery energy level yields the appliances' time of operation. He or she should know that DC charging is at low voltages, typically 9-12 volts, while AC charging is at 220 volts. This knowledge will help prevent improper and damaging use of the system.

We recommend that the training clarify the solar system's capabilities.

Entrepreneurs were occasionally forced to turn away customers with other charging needs because the system's capabilities were not explicitly explained at the training. It should be known to the entrepreneurs that the system is capable of charging almost any electronic device (via the 220 volt AC power strip) and that charging services are not limited to cell phones and lanterns.

We recommend that the DRFN discuss options for system expansion with the entrepreneurs.

A number of the shops reported occasionally not having sufficient energy for the demand of the customers, especially on cloudy days. The DRFN should explain how the system can be expanded for extra capacity, for instance, by connecting an additional solar panel and/or battery. The solar panel appears to provide sufficient electricity to charge a single battery and provide charging services. If an entrepreneur installed two solar panels, more services would become possible. An additional battery for storage would render cloudy days less of a concern.

We recommend that haircutting training be part of the system training.

The financial records show that when a shop is offering haircutting services, which is a large revenue generator itself, cell phone charging revenue also increases. A large number of the shops did not offer haircutting services because the entrepreneur did not feel confident in his or her ability to do so. If all of the entrepreneurs were trained on how to use the hairclipper provided to them, the shops would likely perform better as a whole.

We recommend that the entrepreneurs be required to place and operate the solar system in a location that is separate from their home.

Analysis of the financial records shows that systems generate significantly more revenue if they are placed in locations that are separate from the entrepreneur's home or living quarters. Additionally, out of home systems tend to draw a larger customer base compared to systems in home. In order to provide energy services to the largest number of customers, it would be advisable for an out-of-home-shop-location clause to be included in the purchase contract.

We recommend that, in addition to charging services and products, the entrepreneur offer non-energy products.

Shops which sold non-energy products such as groceries and beverages generated significantly more revenue than shops that did not offer non-energy products. The ability to buy groceries at the same location an individual can charge their cell phone appeals to community members.

We recommend that the entrepreneurs advertise their solar business by whichever means they feel will be most effective.

Advertisement had a large impact on the success of the solar system. When the shop was not signed or the entrepreneur only told a select few individuals about the system, the solar income generated was generally low. Entrepreneurs who advertised actively by word-of-mouth or signage showed a higher cash flow. For this reason, word-of-mouth and signage advertising should be required.

We recommend that entrepreneurs be required to record and report data on templates provided by the DRFN.

Financial records contributed substantially to the analysis of the pilot program. This task could have been made easier by streamlined record keeping. Entrepreneurs should

be practically instructed on how to complete these forms as a part of their initial system training and required to use them throughout their partnership with the DRFN.

We recommend that revenue from the solar system be separated from revenue generated by selling non-energy products in the DRFN records.

A small number of the entrepreneurs reported the total revenue generated at their establishment. This made it more difficult for the DRFN to isolate the revenue was generated by the solar system it provided. If the solar system revenue is separately accounted, a subsequent financial analysis will become easier.

We recommend that the DRFN offer the entrepreneurs incentives for continued recording and reporting income generated from the solar system.

It is likely that future distribution of solar systems by the DRFN will be supported in part by the Solar Revolving Fund. If this is the case, the entrepreneurs will have no obligation to the DRFN and no reason to report their income on a monthly basis once they pay for the system. The DRFN, however, could use this information in a future, larger, macroeconomic analysis of energy shops in Namibia. For this reason, the DRFN should offer incentives such as system maintenance and technical support to those entrepreneurs who continue to report their earnings to the DRFN. It should also be communicated to the entrepreneurs that top performers will likely be promoted to a higher-level energy shop, which would offer more products and services, thereby increasing their overall earnings.

Abstract

A large proportion of Namibia does not have access to grid electricity and will not be electrified for many years. In an effort to provide energy to these areas, the Desert Research Foundation of Namibia has implemented ten “energy shops” in un-electrified areas to provide basic energy services such as cell phone charging and haircutting. The goal of our project is to assess the performance of this DRFN pilot program by evaluating economic success, technical capacity, social implications, and customer satisfaction.

Authorship Page

Heidi Robertson, John Sandbrook, and Chelsea Sheehan all contributed to the research and writing of this report. The following is a breakdown of how the report was written for this project.

Heidi Robertson contributed to the background sections titled 'Electricity Supply in Namibia', 'Decentralized Solar Energy' and 'OGEMP *versus* Business Opportunities'. Ms. Robertson also contributed to the section in the methodology entitled 'Evaluating the shops' surrounding areas'. Additionally she collaborated with Mr. John Sandbrook on the Analysis and Results chapter.

John Sandbrook contributed with the background section entitled 'Energisation Plans', the methodology section entitled 'Interviewing the Entrepreneur'. He also collaborated with Ms. Heidi Robertson on the Analysis and Results chapter.

Chelsea Sheehan contributed to the executive summary, the introduction, the background sections entitled 'Decentralized Solar Energy', 'Business Opportunities with Solar Energy in Un-Electrified Areas' and 'Exploring Existing Rural Electrification Schemes'. Additionally, Ms. Sheehan contributed with methodology sections titled 'Field Work Preparation' and 'Surveying the community members' as well as the recommendation and conclusions sections.

In addition to writing individual sections of this report, Heidi Robertson, John Sandbrook, and Chelsea Sheehan as a group established the project objective, determined conclusions and recommendations, and edited the report for content, grammar, and flow.

Acknowledgements

Our team would like to thank the following individuals, organizations and institutions for their help and support throughout our project:

- The Desert Research Foundation for sponsoring our project, providing a space in which to work, and facilitating our necessary field work.

- Our sponsor at the DRFN, Robert Schultz, was instrumental in providing us with needed guidance in our project goals and methodology. Project liaisons Abraham Hangula and Jimmy Itamba provided us with essential information on the Energy Shop program and allowed us to complete our field work efficiently and effectively.

- Dennis Rendschmidt for his participation in interview development and execution as well as his willingness to collaborate with us on research and analysis within our project as part of his PhD research.

- Professor Reinhold Ludwig and Professor Svetlana Nikitina, from Worcester Polytechnic Institute, for their overall guidance and support throughout our project.

- The Polytechnic of Namibia and Worcester Polytechnic Institute as the collaboration of these two institutions made our trip to Namibia and completion of this project possible.

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List of Acronyms

ABB - Asea Brown Boveri

DEP - decentralized energy planning

DRFN - Desert Research Foundation of Namibia

EPOGES - Energy Profiling for Off-Grid Energy Solutions

GWh - Giga Watt hours

kV - kilo Volt

kWh - kilo Watt hours

MW - Mega Watt

MME – Ministry of Mines and Energy

OGEMP - Off-Grid Energisation Master Plan

PV - Photovoltaic

PVS - Photovoltaic System

REDMP - Regional Energy Distribution Master Plan

SAPP - South African Power Pool

WPI - Worcester Polytechnic Institute

WWF TZ - World Wide Fund for Nature, Tanzania

CHAPTER 1: INTRODUCTION

Electricity is a pillar of modern life and often taken for granted, especially in developed places such as the United States and Europe. Developing countries, on the other hand, struggle with economic and societal growth due to, in part, a lack of access to this vital resource. Southeast Asia and Africa are areas most affected by this problem. At 23%, Africa has the lowest electrification rate, or percent of residents with electricity, among modern world regions (Wolde-Rufael, 2006). A history of energy consumption in the world over the past three decades shows an increase in every region with the exception of sub-Saharan Africa, which has experienced no increase at all. As the population of sub-Saharan Africa increases rapidly, the projected date for 100% electrification is extended further into the future, with the most recent predictions being 2087 or later (Wolde-Rufael, 2006).

Due to this lack of full electrification in Africa, each year US$17 billion is spent on inefficient, dangerous, and polluting energy fuels like kerosene (Ramachandran, 2008). Additionally, many developing governments spend millions of dollars in taxes to import energy from developed countries. Efficient and reliable sources of electricity are necessary for sub-Saharan Africa to achieve a sustained rate of economic and social growth and begin eliminating its high rate of poverty.

Namibia is one of the countries that suffers from a lack of electricity. Although it is considered the second most developed country in Africa, over 60% of Namibians do not have access to grid electricity. Extending the electricity grid to thousands of small, rural settlements in this sparsely populated country is technically challenging and extremely costly. According to Namibia's Ministry of Mines and Energy (MME), their government will not be able to provide grid electricity to even half of the over 106,000 households in rural settlements within the next twenty years (Schultz and Schumann, 2007). In an effort to speed the electrification process and provide basic electrical services to as many people as possible, the government is supporting two energy initiatives: the Regional Energy Distribution Master Plan (REDMP) and the Off-grid Energisation Master Plan (OGEMP). The REDMP outlines the plans for extension of Namibia’s electricity distribution grid, while the OGEMP proposes alternative electricity solutions for those areas that are unable to be electrified.

The government has plans in place for electrification and energy alternatives, but does not have sufficient financial resources to initiate them. With funding from the European Union and the World Fund, the Desert Research Foundation of Namibia (DRFN), a non-governmental organization, has independently implemented an alternative energy solution called 'Business Opportunities with Solar Energy in Un-Electrified Areas' which closely resembles the OGEMP. This pilot program is the first step in providing electricity to rural areas of Namibia. Its aim is to eradicate poverty and assist the nation of Namibia in entering a state of economic stability and growth.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

A proposed solution to rural electrification detailed in the OGEMP is the establishment of solar powered 'energy shops' in un-electrified areas throughout Namibia. The goal of these energy shops is to provide charging services for cell phones, hairclippers, and 12-volt car batteries with electricity produced by a photovoltaic (PV) system. The DRFN installed Namibia's first energy shops in October 2009 through a program entitled 'Business Opportunities with Solar Energy in Un-Electrified Areas'. As this is a new program, it is thus far unknown whether or not these shops can be economically effective and what kind of impact they may have had on the surrounding community. This chapter will describe the Namibia's energisation problems, why they arose and what steps have been taken to help those without access to grid electricity. It will also describe the energy shops and the services they provide, concluding with reviews of other off-grid energisation plans in other countries in order to gain an understanding of alternative attempts to solve this problem.

2.1 Electricity Supply in Namibia

The economic and societal development of a modern nation is greatly dependent on the country's access to electricity. In the United States, a large number of utility corporations provide electricity to virtually every household in the continental 48 states. The power grid within the United States that delivers electricity to cities and towns all over the country is extensive and well developed. In developing countries, this is not the case and it can be a significant hindrance to future development and economic growth. "Often in many developing countries, grid electricity access does not expand beyond urban environments, leaving many rural residents without electricity" (Rothermel, 2007). These rural residents use less efficient and more labor intensive methods to perform everyday tasks and consequently will not develop at the same pace as the urban portions of the country. This lack of energy use in rural areas is usually due to a deficient or non-existing electric grid that cannot spatially cover all local residence.

Having to rely on an underdeveloped electric transmission system is particularly pertinent in Namibia. Between 60-70% of the residents of Namibia do not have access to grid electricity, the majority of whom are rural residents (DRFN, 2009). As a result, there remains large numbers of people who have to rely on alternative energy means

(primarily wood and paraffin fuel) for heating, cooking, lighting, ironing, and water heating (Utonih, 2001). These energy sources are not as efficient or reliable as grid electricity, can be costly to acquire, are not necessarily environmentally friendly, and require more physical exertion to obtain and use. If electricity is available in both urban and rural areas of Namibia it is likely that these sections of the country will grow and develop. Unfortunately, without significant financial resources the current grid system cannot be extended to deliver electricity to all of the country's citizens. Currently, electricity is generated by three main power stations relying on coal, diesel, and hydropower. Furthermore, the country relies heavily on energy imports from Zambia and South Africa (DRFN, 2009). These power station locations and their main transmission lines are seen in Figure 1 (NamPower, 2009).

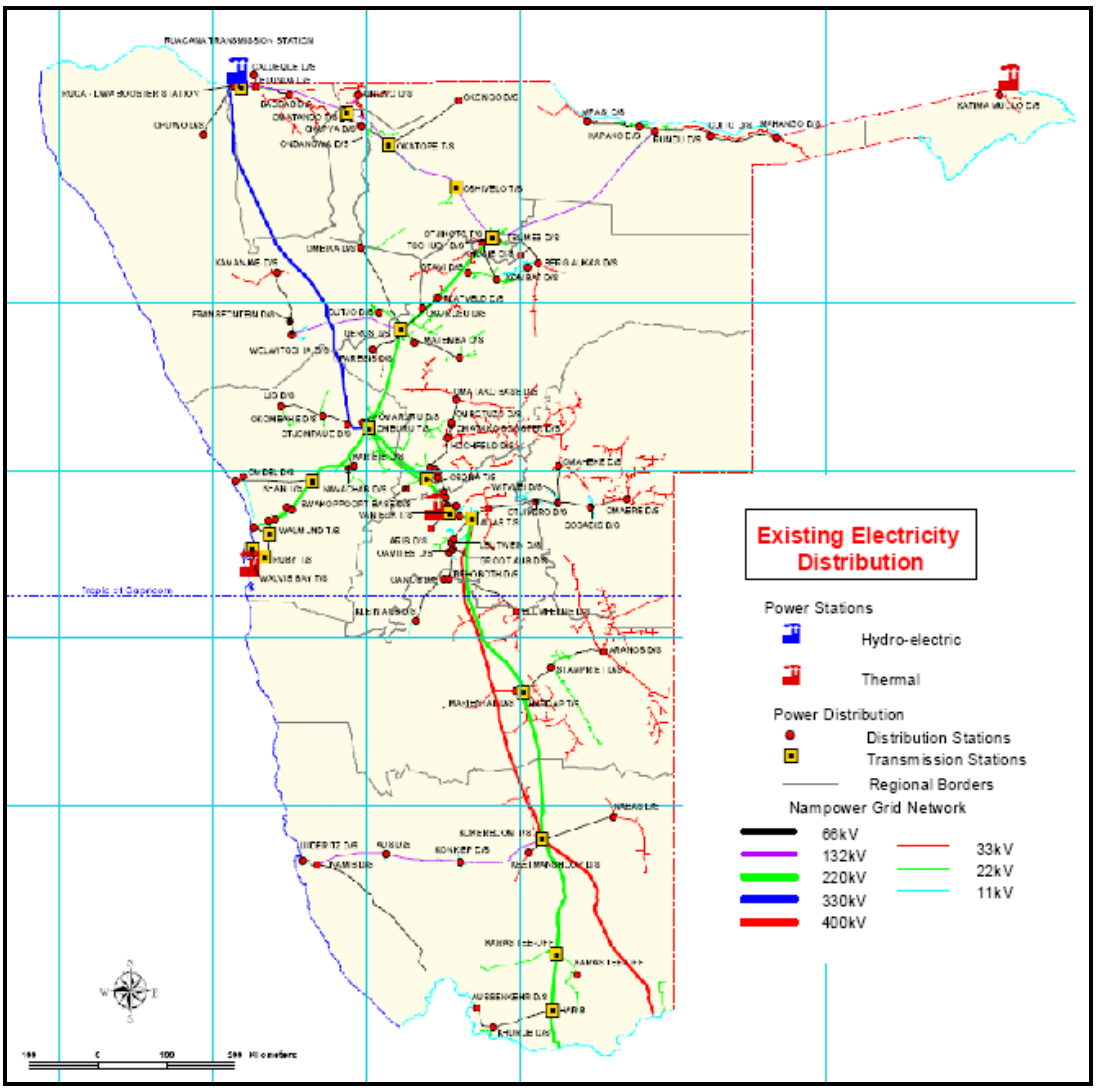


Figure 1: Power station locations, types of energy generation, and main transmission lines
(Retrieved from: http://www.family-hipp.co.nz/site/klausdierks/Energy/index.html)

The hydro powered Ruacana station in northern Namibia generates the most power, approximately 240MW, for distribution to the entire country except the north-eastern Caprivi region (NamPower, 2009). Van Eck power station, outside of Windhoek, operates on coal power and generates roughly 120 MW of power (NamPower, 2009). The Paratus station on the western coast of Namibia is used mostly as a standby station for the coastal area with four diesel powered generators producing at maximum 6.4 MW of power each (NamPower, 2009). Namibia's main transmission line extends directly into South Africa to several of its power stations. The Katima Mulilo coal station in the easternmost portion of the Caprivi region is operated with coal imported from Zambia. The station is also connected to a hydro power station located in Victoria Falls in Livingstone, where Zambia obtains most of its power (NamPower, 2009). These outside power sources that Namibia has to rely on are offered through its membership in the association of Southern African Power Pool (SAPP). SAPP is composed of power utilities from Angola, Botswana, The Democratic Republic of the Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. Half of the country's power comes from other countries, mainly South Africa with contributions from Zambia, Zimbabwe, and Mozambique (NamPower, 2009). This can be seen in Figure 2 from NamPower's 2009 Annual Report showing electric energy in units of Giga Watt hours (GWh) fed into Namibia's main energy transmission system. It reports energy supply by South Africa (Eskom), NamPower, and other countries.

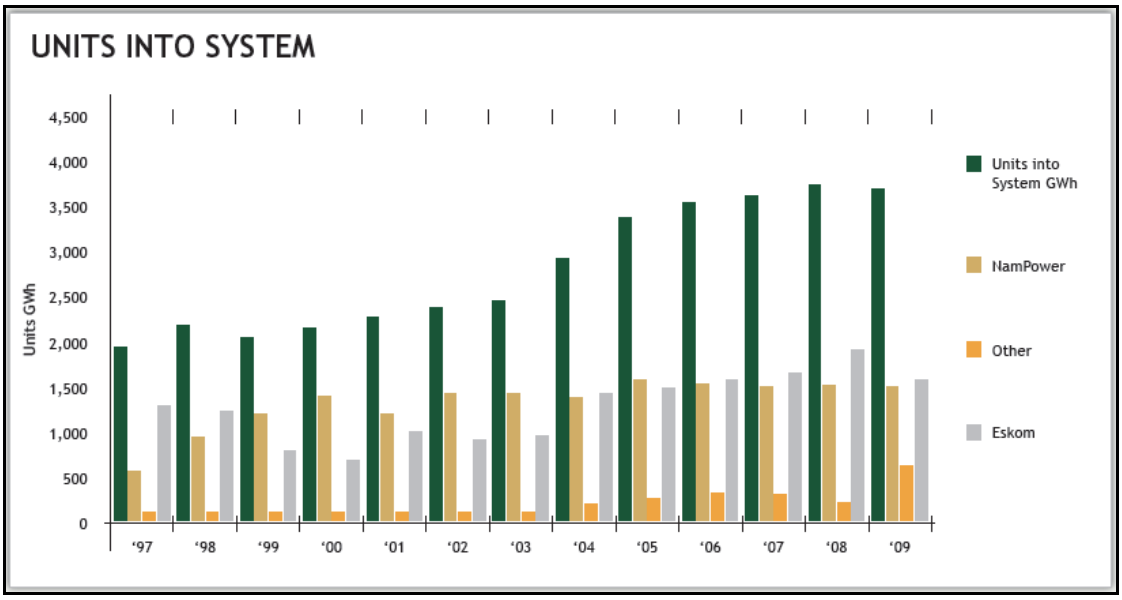


Figure 2: Units of GWh supplied into Namibia's national electricity grid (called System) from NamPower, South Africa (Eskom), and other countries
(NamPower, 2009)

According to the SAPP, Namibia's peak power demand between April 2007 and March 2008 was 490 MW. NamPower only has the capacity to produce 360 MW of available power, which is often not produced in full. Figure 2 makes clear that the country has to rely on outside sources to obtain the majority of their energy. Consequently it leaves Namibia vulnerable to problems resulting from policy changes and resource depletion in the countries on which it depends. Based on these numbers and the power amounts produced by the generation stations, combined with external energy imports, it is apparent that lack of electricity is not the cause of Namibia's high rate of unelectrification. Namibia simply does not have the ability to distribute electricity to all of its citizens.

Occasionally, there is insufficient energy in the system to meet the demands of those businesses and households connected to the grid. In March 2010 a power outage at Koeburg, a nuclear power station in South Africa, combined with a slow rainy season in the Kunene River area, forced NamPower to take energy conserving actions (Dentrlinger, 2010). NamPower has developed a five-step, color coded alert system to notify recipients as to when the system is under strain, and what actions they should take. For example, a green alert indicates limited strain on the distribution system, and customers are asked to switch off unused devices and lights in rooms that are not occupied. Additionally, load shedding, or intentional alternating power outages between areas, has been used in the past to alleviate strain on the system (NamPower).

The existing electricity system, power stations and grid, attempts to relay what power it can supply throughout the country's large land expanse through distribution stations. This transmission system uses approximately 31,000 km of power lines that range in voltage from 11 kV to 400 kV. The kilo Volt (kV) value denotes the root mean square (rms) voltage magnitude the line carries. A high kV value indicates the transmission line is used for long distance distribution. For example, a 400 kV line runs the entire vertical length of Namibia. Lower kV lines branch from this main connection distributing local energy, typically to residential areas. Five transmission lines carry voltages between 66-400 kV while four distribution lines carry voltages below this range (NamPower, 2009). Local distribution lines cannot support a large area and great numbers of lines must be put in service to provide electric power outside of the main transmission grid. Installing power lines and further maintenance of these lines is costly and time consuming. This is why a large area of the country remains un-electrified and

the majority of the rural population has continued to live without power. Figure 3 illustrates that there are large areas in which villages and settlements remain unconnected to the grid system. On the left, the map shows population distribution in Namibia in people per km^2, and on the right, the transmission and distribution system.

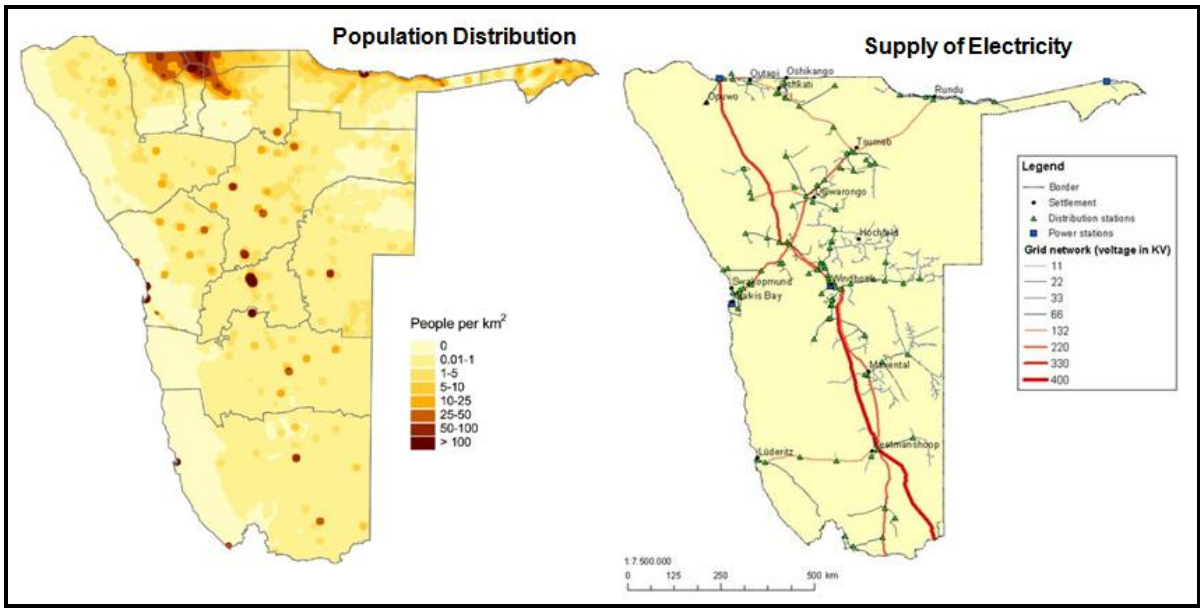


Figure 3: Population Distribution (l) v. Transmission and Distribution Grid in Namibia (r) (Mendelsohn, J. (2002). *Atlas of Namibia: a Portrait of the Land and Its People*. Cape Town: David Philip)

When these maps are compared, it can be seen that there is a need to increase electrification throughout the nation, especially in terms of power generation and distribution outside the main population centers of Windhoek, Walvis Bay, Swakopmund, and the extreme northern region near Angola. This would help the country's economic development in rural areas where agriculture and mining prevails.

2.2 Decentralized Solar Energy

The centralized energy system in Namibia is not successful in delivering electricity to the entirety of the country. In developing countries like Namibia, government funding is more often than not simply unable to provide every resident with a connection to the electricity grid. At approximately 2 million people, Namibia's population is very small relative to its size, resulting in small clusters of people living outside of the economically feasible range of the electric grid. For this reason, the concept of decentralized energy planning (DEP) has received significant interest (Weidlich, 2008b). The goal of DEP is to efficiently utilize all available resources to

provide energy to remote locations. DEP takes advantage of a specific area's most abundant natural renewable energy source, such as solar, wind, or hydro power.

According to researcher Weidlich, "...Just 64 square kilometers covered with solar panels would provide enough electricity for Namibia, the size of an average farm of 6,400 hectares and we would be self-sufficient and need not rely on electricity imports any more" (Weidlich, 2008b). In an interview with *The Namibian* in 2008, a commercial farmer refers to establishing a decentralized energy system which utilizes solar energy as the most feasible and sustainable way to increase power generation in Namibia. This choice for a renewable power source utilizes one of Namibia's most abundant natural resources: the sun. With some areas of the country weighing in at the sun's maximum power density of 1200 watts of solar radiation per m^2 per day, Namibia is one of the sunniest countries on earth. Figure 4 shows the spatial distribution of an abundant amount of solar radiation in kWh per m^2 per day over the entire country (Mendelsohn, 2002).

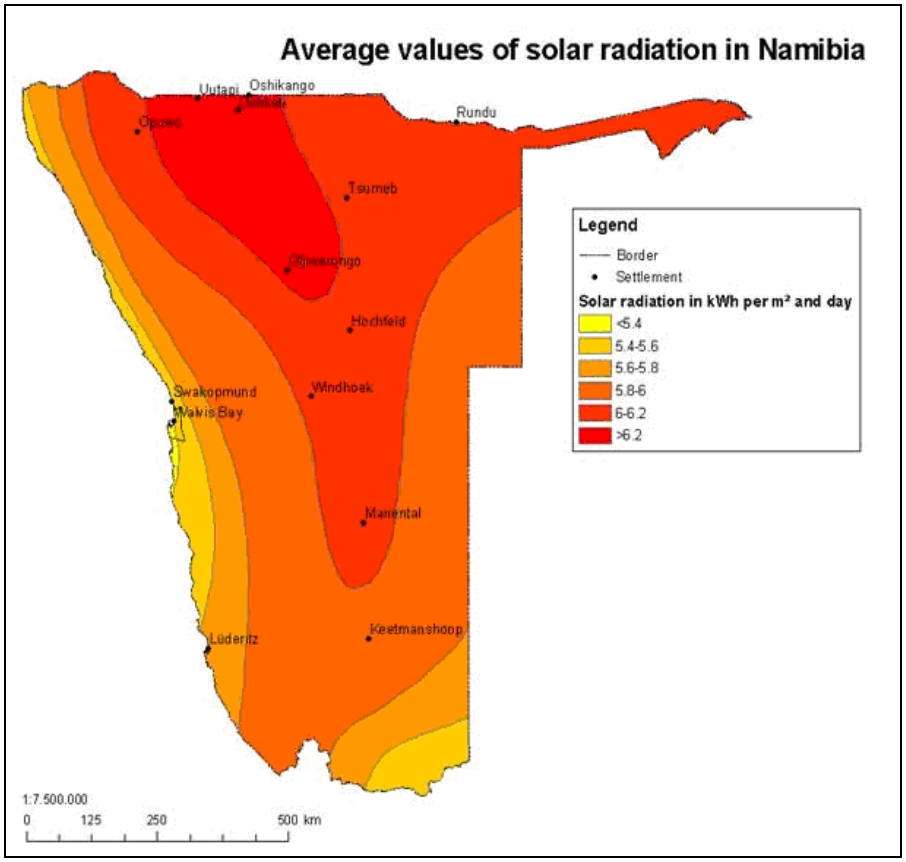


Figure 4: Average values of solar radiation in Namibia in kWh per m^2 per day
(Mendelsohn, J. (2002). *Atlas of Namibia: a Portrait of the Land and Its People*. Cape Town: David Philip)

Utilization of this copious source of energy could, over the long term, help alleviate problems of power generation. Solar panels create energy using little space while producing minimal waste. The abundant availability of intense sun radiation across the country will not be depleted in the near and far future, making it an ideal alternative to grid electricity in Namibia (Bubenzer, Bolten, et al, 2004). As detailed by the Ministry of Mines and Energy in the Off-Grid Energsation Master Plan (OGEMP), Namibia plans to harness this clean, albeit initially expensive, resource and use solar energy as a means to increase power generation and overall electrification, concentrating in remote areas that are unable to be connected to the electric grid.

Solar energy also appears to be an economically wise option for Namibia. A single 80-W solar panel in Windhoek can generate an average of 3.80 kWh of electricity per day (Solar Panel Calculator, 2009). Attaining the same amount of electricity for one year would cost N$2,189.85 if supplied from the standard electric grid. A typical solar panel and battery combination costs N$4,700, resulting in pay off period of slightly more than two years. An increase in households with personal solar systems would allow NamPower to import less electricity from countries like South Africa and Zambia, which is heavily tariffed (Weidlich, 2008a).

2.3 Energisation Plans

Since gaining independence in 1990, the Namibian government has been attempting to expand the electric grid to provide electricity to a larger proportion of the country. This Rural Electrification Program was commissioned by the government as part of the Regional Energy Distribution Master Plan, or REDMP (Ministry of Mines and Energy, 2006). The program aims to expand both the power stations and transmission lines throughout the country through NamPower, the country's main semi-government energy supplier, in association with the Ministry of Mines and Energy (NamPower, 2009). Starting in 1991, the program began electrifying densely populated sections of the country starting with the extreme northern and southern regions. While this effort has provided energy to heavily populated areas of Namibia, only around 13% of rural settlements receive power from this main system (DRFN, 2009). It is not economically viable to connect every rural settlement to the main grid. For example, the program had spent N$50 million (over US$6 million) to connect 80 villages and settlements to the grid in 2003, with the cost rapidly increasing as the grid connections become

longer(NamPower, 2009). Approximately 1,543 rural communities will be electrified over the next 20 years by the REDMP, as outlined by the Ministry of Mines and Energy, while there will remain 4,315 un-electrified communities (DRFN, 2009). After the program has reached its completion, a large number of rural settlements will remain without electricity, as seen in Figure 5 below.

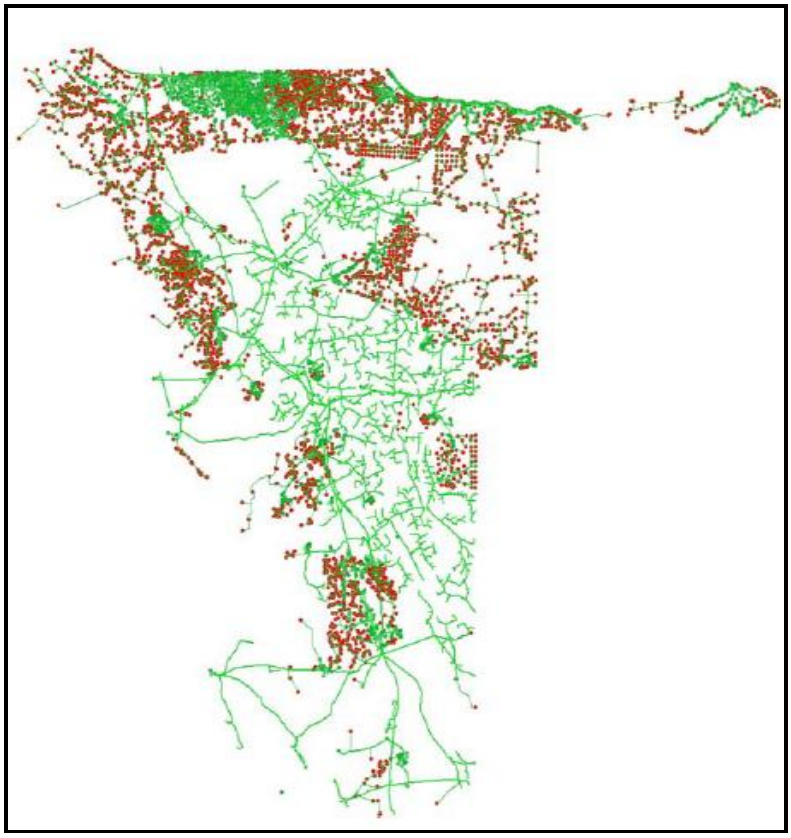


Figure 5: Future Grid Map of Electrified and Un-electrified Villages and Settlements in Namibia
(Retrieved from: http://www.drfn.org.na/pdf/energy_factsheets/offgrid_minigrid.pdf)

The green lines in Figure 5 indicate the villages and settlements that will gain electricity within the 20 year period of the program, while the red dots indicate the settlements that will remain without electricity (DRFN, 2009). These un-electrified areas need to find a method of accessing electricity to perform day-to-day tasks as well as to aid technical and economical development along with the rest of the country.

With this in mind, the government has commissioned the Off-Grid Energisation Master Plan for Namibia (OGEMP) in partial collaboration with the DRFN. Regions are classified by their access to the energy grid. Off-grid denotes settlements that will not have access to the grid after program completion and pre-grid denotes areas that will not receive power for an extended period of time. Within “grey” areas, it is not known

what future energisation will occur; informal settlements fall under this section as they are not counted in the government's energy plan (Schultz & Schumann, 2007). OGEMP places "energy shops" in off-grid, pre-grid, and "grey" areas to provide energy technologies and services to the approximately 106,544 households that will remain un-electrified at the conclusion of the program. These shops will sell basic energy supplies and offer energy services using a solar energy system (Schultz & Schumann, 2007). This system allows all these areas access to energy through renewable energy technologies as opposed to the main grid while also stimulating the economy through the shop scheme. Although the plan was drafted and accepted nearly three years ago, the government has yet to officially implement any energy shops in Namibia.

2.4 Business Opportunities with Solar Energy in Un-Electrified Areas

The DRFN has initiated and implemented a pilot program to the official plan outlined in OGEMP. This initiative, entitled 'Business Opportunities with Solar Energy in Un-Electrified Areas', is funded externally and operated independently of the Namibian government and OGEMP, but has similar features in order to be used as test for the future success of the OGEMP.

2.4.1 Funding the pilot program

In order to implement its program independently, the DRFN needed to apply for funding from an organization outside the Namibian government. Due to its similar goals and interest in Namibian affairs, the Sustainable Energy Project Support program under WISIONS at the Wuppertal Institute (Wuppertal, Germany) agreed to award a grant to the DRFN for its Business Opportunities with Solar Energy in Un-Electrified Areas program. In the project proposal, the objective of the program is stated as "to encourage rural and informal settlements' entrepreneurship, enhance off-grid communities' access to modern energy services and promote renewable energy technologies through establishing rural solar energy-based businesses to provide basic energy services to un-electrified communities". The DRFN hoped to gain sufficient funding to implement ten energy shops, including the cost of purchasing the system, training programs, and monthly monitoring of business practices. The proposal identifies necessary criteria for the area in which to establish an energy shop. These criteria include the following: the area must be un-electrified, it must be rural or peri-urban, and it must have a sufficient

customer base for marketing. The proposal also outlines the projected technical viability, economic feasibility, environmental benefits, replicability, marketability, and societal issues regarding the shops. Additionally, an implementation strategy and timeline was outlined and presented (Moses, 2008).

In April 2009, the DRFN was granted 90% of the funding requested for the project, an amount totaling more than N$500,000 (US$69,000). Shortly thereafter, the process of selecting locations, shop entrepreneurs, and photovoltaic systems began (Moses, 2008).

2.4.2 Area and entrepreneur selection

The DRFN spent nearly six months evaluating different options for shop locations as well as individuals to receive the systems. As the criteria for an appropriate location had already been established, DRFN officials collected the names of twenty-four individuals residing in such areas to be evaluated as candidates for receiving a solar system. The DRFN chose not to open the program up for general application; rather individuals were identified based on personal recommendations (A. Hangula, personal communication, March 2010).

The twenty-four candidates were asked to distribute an Energy Profiling for Off-Grid Energisation Solutions (EPOGES) survey in their respective community and return the results to the DRFN. This survey is an energy and market assessment to determine if there is sufficient demand for energy products in the community and if the community has funds for these energy products. This task was assigned to gain knowledge of the communities and also as a means to evaluate the candidates' pro-activeness and dedication with respect to the program. The results of the EPOGES as well as the information collected in a recruitment evaluation questionnaire completed by the potential entrepreneurs were used to determine the ten individuals who would ultimately receive the solar system (A. Hangula, personal communication, March 2010).

The ten chosen individuals were then asked to attend a one-week training session at the DRFN. The training session covered topics such as basic technical aspects of the system, business management, and record keeping procedures and expectations (Moses, 2008). Seven of the new entrepreneurs attended the training session. One entrepreneur was unable to attend and sent a substitute in her place, while two other received their solar systems at a later date. At the conclusion of the training, the

entrepreneurs signed a contract and were sent back to their community with one of two types of solar system. Both solar systems, one provided by Solar Age Namibia and the other by Terrasol, consisted of an 80W solar panel, a 12V battery, an inverter, an AC power strip, ten assorted DC cell phone chargers, a hairclipper, two wired lights, and two portable LED lanterns (A. Hangula, personal communication, March 2010). The entrepreneurs were given six months to use the system in their business and were allowed to keep the earnings as long as they followed the contract guidelines. At the end of the six month period, an evaluation of the viability of each business was completed to determine if the project was a success.

2.4.3 Provided services

The minimum requirements for the solar system provided to the energy shops were established prior to the purchase of the systems. Each system has the capability to concurrently charge ten cell phones (via DC power) per day, operate an AC powered hairclipper for two hours per day, charge three lanterns (via DC power) per day, and operate two lights for three hours a day (via DC power). By purchasing an additional battery and/or solar panel, the storage and capacity of the system can be increased (A. Hangula, personal communication, March 2010).

Each shop is expected to offer cell phone charging, lantern sales and charging, and haircutting services. As most of the entrepreneurs operated businesses previously, the solar system is often located at their existing business, which typically offers a variety of products including food and drinks. Some shops offer cell phone accessories such as phone covers and network airtime minutes. The shop owners are permitted to set prices at their own discretion, but are required to submit monthly financial records to the DRFN. These financial records should adhere to basic accounting principles and detail profits gained through the use of the photovoltaic system in order to properly assess monthly net income.

2.4.4 OGEMP *versus* Business Opportunities

While many of the services of these pre-phase shops are similar to that of a basic shop established through the OGEMP, the two programs are dissimilar in goals, timeframe, and scope. The OGEMP creates a shop which offers a variety of services and products as well as a loan program to assist those who cannot afford energy services

and products in order to extend basic electrical services to off-grid areas, while the DRFN business system program offers three basic services and strives to create a business entity through these needed services. Due to its goal of increasing electrification throughout Namibia, the OGEMP extends over twenty years in order to establish the large number of shops called for within the plan and to offer ample time for the energy shops to grow and develop. The DRFN plan has a time frame of one year with an evaluation of the 10 established shops after six months of operation. Each shop is also expected to be a viable business based solely on the photovoltaic system with no financial assistance from the DRFN before this period of time has been completed. The OGEMP has marked off various points over the twenty year period for both evaluation of energy shops and allocation of funding within all aspects of the program. It is partially due to OGEMP's large timeframe and scope that the DRFN has implemented their plan. If the DRFN's energy shop program is successful on the small scale it provides supporting evidence to conclude that the larger OGEMP may also be successful.

2.5 Exploring Existing Rural Electrification Schemes

One of the first areas of rural renewable energy systems we explored was the different types available. Renewable energy options include wind, solar, and hydro powered systems, to name but a few. The type of system installed is based largely on location, resources found in a particular area, and available capital for the establishment of an energy system. Energy generation is especially difficult in places like Namibia where there are small clusters of people located all over the country. For this reason, alternatives to grid electricity should be explored. Hydro-power appears not to be an option for all of Namibia because the only feasible moving water source is located in the northern part of the country along the border with Angola. Namibia has already utilized this source to the best of its abilities. In some cases hybrid energy systems are installed, combining two or more energy generation systems.

The following are two examples of remote energy systems in areas similar to Namibia that we studied in order to gain knowledge of the different types available. Additionally, it helped us gain insight to the logistics of implementing such a system. A combined wind and solar energy system was installed in the South African village of Lucingweni in 2004. The system was evaluated for three years and was eventually

deemed not economically viable for a variety of reasons. One of the main reasons was that it did not generate enough energy for the community's needs. The system was able to generate 3kWh per day per household; however, this still did not meet the demand (Brent and Rogers, 2010). To facilitate success, it is important that the energy demand and the useable energy a system can output be extensively studied before it is implemented. As an example, in the village of Ngarambe, Tanzania in 2001, a diesel energy system was installed in a remote village in lieu of a more environmentally friendly one due to the costliness of photovoltaic (PV) cells. Solar energy alone was chosen to power the energy shops due to Namibia's many hours of daylight and high concentrations of solar radiation.

As villages in need of rural electrification are often unable to afford electricity on their own, they exert pressure on their country's government and other more developed countries to provide financial support. For instance, the Lucingweni mini-hybrid system was financed by the South African Department of Minerals and Energy. The agency's inability to continue funding the project partially contributed to its designation as not economically viable. Implementing a renewable solar energy system is a large undertaking and most are intended to be long-term installation in a community. Given this reality, it is crucial that one or more sponsoring agencies commit to funding for a pre-determined length of time. In the case of the diesel energy system in Ngarambe, the Asea Brown Boveri (AAB) corporation and the World Wide Fund for Nature, Tanzania (WWF TZ) provided the initial funding. Both organizations established beforehand that responsibility of the system's operation would fall to the community after an inauguration period (Egles, 2005).

Against this background, the energy shops of Namibia are very unique. Although many countries struggle with rural electrification and are constantly working towards a solution, there is no comparable system that features shops which provide and sell energy services. The socio-economic impacts of electrification in Namibia were explored and documented in 1999 by researchers at the University of Cape Town in South Africa (Wamukonya and Davis, 1999). A critical aspect of the document was a summary of responses from individuals who live in areas that had recently been electrified, and how the electrification had changed some of their day-to-day activities. Topics included cooking, access to TV and radio, ironing and refrigeration, safety, health, and education, among others (Wamukonya and Davis, 1999). Although the individuals surveyed had

solar home systems installed, they provided a baseline for what services should be available in the energy shops.

Community reception is important when proposing and installing an energy shop or any type of energy system. If the community's attitude towards an energy system is not positive, the system is likely to be unsuccessful. In Lucingweni, skepticism over ownership of the grid contributed to its lack of success. Residents of the village were neither well informed nor fully aware of all aspects of the renewable energy technology that had been implemented in their community. This made the system vulnerable to failure (Brent and Rogers, 2010). A similar problem was encountered in Ngarambe. The residents actually did not want electricity in their homes because they were uninformed of its benefits. Another contributing factor was the large, devout Muslim population of the village. Many people, including the village's doctor, were opposed to the concept of electricity in general, something the project planners were not aware of in the beginning stages of the project. When the time came to train a select few villagers how to operate the system, their religious activities rendered them unable to give as much attention to the system as was necessary (Egles, 2005). Problems such as these demonstrate the necessity to extensively research a community preparing to install a new energisation system. In the case of the energy shops, individuals should be able to choose whether or not they would like to utilize these services. Moreover, screening and training of the entrepreneurs will still be necessary to ensure they are equipped to take on the responsibility of running the shop.

The two energisation systems discussed in this section were evaluated through a variety of methods. Strategies included surveys, interviews, and focus groups. We will employ similar methods in our own evaluation of the energy shops. A detailed outline of our methodology can be found in the following chapters.

CHAPTER 3: OBJECTIVE

The overall goal of our project is to assess the success of the DRFN pilot program 'Business Opportunities with Solar Energy in Un-Electrified Areas'. This goal will be accomplished through data analysis, customer surveys, entrepreneur interviews, and first hand observation.

We will evaluate economic success, technical capacity, customer satisfaction, and social implications of the shops. Our evaluation will provide suggestions and recommendations for improvement that can be applied to strengthen the DRFN pilot program as well as the Off-Grid Energisation Master Plan. Specifically, the following items define our sub-objectives:

- Develop evaluation criteria for the energy shops based with direct input from the DRFN.
- Compile financial documents into spreadsheets and analyze this data by each developed evaluation criterion.
- Interview shops owners and survey customers and non-customers to document community experiences and gain an understanding of shop activities.
- Conduct first hand observations of the shops and surrounding areas to evaluate differences and potential factors on shop performance.
- Analyze collected data and determine conclusions on economic performance, technical capacity, customer satisfaction and social implications.
- Suggest improvements to the shops for future expansion, and identify the requirements for existing shops.

Our detailed implementation plan to accomplish our goals is presented in the following methodology chapter.

CHAPTER 4: METHODOLOGY

4.1 Field Work Preparation

Upon arrival at the DRFN we met with our sponsor, Robert Schultz, and project liaisons, Abraham Hangula and Jimmy Itamba, to discuss project goals, logistical support, and implementation strategies. At this meeting, the DRFN provided us with the required deliverables they expected us to furnish throughout the course of our assignment as well as a time-line of due dates for these deliverables and travel dates for our field work. At that time, we gained access to documentation regarding the funding and implementation of the DRFN's energy shop program. This documentation included the initial program proposal to the Wuppertal Institute, quotation requests and technical specifications for the solar systems, training materials, the EPOGES surveys distributed by the entrepreneurs, and a recruitment evaluation for the entrepreneurs. This allowed us to develop an understanding of the requirements for the energy shops set forth by the DRFN, the time frame and budget of the project, and the technical capacity of the solar system.

The DRFN had also collected each energy shop's financial records collected since the shops' inauguration in October 2009. The records contain daily transactions of income generated using the photovoltaic system since each shops' implementation. We compiled what data we had into an Excel spreadsheet. The records of each shop were organized by services rendered and totaled over all months in order to determine what portion of the shops' total income is generated by which services. This data was then displayed in a bar graph of total income by month with divisions to show the income from separate products and services. This information was useful to us since it determined which products are sold most often, and which services are used most often in various locations. The results of the total income from each shop were then compiled in a table and displayed in graphical form for each month to show the sales trends over the six months of shop operation.

Once our preliminary financial data collation was complete, we used the information along with results from an Energy Profiling for Off-Grid Energisation Solutions (EPOGES) survey and recruitment evaluation questionnaires to develop entrepreneur profiles. This also served as a means to develop entrepreneur-specific questions for our interviews. Each profile includes a map depicting the shop's location,

descriptions of the location and entrepreneur, an overall sales summary, a market analysis, reports on panel efficiency, and any reported difficulties with the system. Additionally, shop-specific questions were developed based on any anomalies found in the data. The goal of the profiles was to familiarize ourselves with each shop and entrepreneur before visiting them in the field.

Two of the energy shops are located just outside of Windhoek in the informal settlement of Havanna. We visited these shops during the first week to expose ourselves to the energy shop concept and how it is embedded in the community. This visit gave us a baseline idea of what we would need to search for and take note of at the remaining eight sites. Furthermore, speaking to the two entrepreneurs gave us insight as to what information we would like to know from their point of view.

The following week, we conducted another meeting with our sponsor and project liaisons to further clarify the information they would like us to gain through interviewing the entrepreneurs and surveying the customers. As a result, we were able to draft questions for the entrepreneur interview, and develop a survey for community members. The final versions of the interview questions and customer survey can be found in Appendix B and C, respectively. We visited Havanna for a second time to conduct a 'dry run' with our interview questions and surveys. This proved helpful, as we were able to return to the DRFN and edit the documents before leaving to visit the remaining eight shops.

After visiting the Havanna shops, it was also apparent that an area evaluation would need to be drafted. This area evaluation would make note of differences in the surroundings of each shop, such as terrain and population density, and evaluate the shop itself in structure and quality. Such outside factors could be influential in shop success and would need to be evaluated in our results.

4.2 Field Work Data Collection

In order to draw conclusions and make recommendations regarding the energy shops, we had to do more than simply review financial records. It was necessary for us to visit and spend time at each shop and in the surrounding community. Our project liaisons, Abraham Hangula and Jimmy Itamba, accompanied us on the trip to aid us in translation. We were also joined by Dennis Rendschmidt, a PhD student from Germany

who collaborated with us as part of his thesis research. The following sections detail the approach we undertook to carry out our data collection at each location.

4.2.1 Interviewing the entrepreneur

Since the entrepreneur is the integral part of each shop, we dynamically interviewed each entrepreneur who received a solar system from the DRFN. Each interview had the goal of determining how the shop performed economically and socially and its root causes. Such interviews also enabled us to delve deeper into any anomalies found at each shop. Personal interviews were chosen because of the relatively small sample size and the amount of information needed from each entrepreneur. Of the ten entrepreneurs who were originally identified to receive a system, only eight systems remained fully functional at the beginning of our interview process. Although a set list of questions was used, summarized in Appendix B, additional questions were developed immediately after speaking with each of the entrepreneurs.

After arriving at each site, language considerations had to be taken into account. Depending on the language of the entrepreneur and the expected language of the customers, our project liaisons, Jimmy Itamba and Abraham Hangula, were divided between customers and the entrepreneur to provide language translations. If possible, English was used to prevent any miscommunications, although this approach was not always successful. Differences in accent and choice of words caused miscommunications as well. When such problems were identified, we relied on either Mr. Itamba or Mr. Hangula to translate our questions into the entrepreneur's natively spoken language.

Before our interviews, both translators were briefed on our questions and the information we desired to gather in order to prevent problems incurred with translations. This allowed the translator to ask questions with the intention of gathering the information we required. If the entrepreneur misunderstood our choice of words, the translator was able to change the question in a way the shop owner could comprehend.

Excluding the translator, two people were always designated for interviewing the entrepreneur. A lead interviewer was decided upon before the questions began; however, both interviewers asked questions of the entrepreneur. This facilitated a discussion type atmosphere which was helpful in gathering more information from the

entrepreneur than expected. Our questions were designed to provide sufficient information for the subsequent analysis discussed in Chapter 5. However, extra information that the entrepreneurs revealed further enabled us to evaluate their performance.

4.2.2 Surveying the community members

Surveying each shop's community members was an important task to assess how well the shop was functioning. We chose a survey approach to ensure that the information gathered was consistent among all participants. We used a single survey for both customers and non-customers, omitting questions not applicable when necessary. The survey, which can be found in Appendix C, covered a variety of topics including personal sources of energy, cost of charging, transportation to the shop, and overall satisfaction. If the community member was a customer, we gathered a variety of information. Specifically, we inquired what energy sources were used at home, the cost and frequency of cell phone charging, if the price of cell phone charging is deemed fair, if the shop was open when needed, if security is provided, and whether the entrepreneur was friendly, helpful, and knowledgeable in regards to the solar system. For non-customers, we asked awareness of the energy shop, what energy sources were used at their homes, if the prices the shop charges are fair, and if there are other locations where charging services are available. As most of the people we interviewed did not speak English, we conducted the survey in an interview format with the aid of a translator. We asked the translator to explain who we were, what we were doing, and what we planned to do with the information gathered prior to asking any questions.

The number of interviews collected at each shop varied greatly, depending on size and density of a given community's population. We collected at least five interviews from each location, with ten being the largest number collected. Although we are aware that these numbers are not significant to provide statistically viable data, we nonetheless concluded in conjunction with our sponsor that they are valuable for an initial assessment, enabling fair conclusions and recommendations for the needs of the DRFN.

4.2.3 Evaluating the shops' surrounding areas

While we conducted the same interviews of customers and entrepreneurs at each location, the data gathered from each survey can be skewed due to the region in which the shop was located. Responses to questions such as "What type of energy products do you use in your home?" and "Are there other locations where you can obtain energy services?" could vary greatly given surrounding terrain or the proximity of a village to the nearest grid location. To account for these large differences, we conducted an area evaluation at each shop. This evaluation, which can be seen in Appendix D, took into account the size of the settlement or village, the layout and quality of the structures therein, the terrain of the area, the distance to the nearest electricity grid, and the location and structure quality of the shop itself. Any other notable anomalies were taken into account. The area evaluation also included a photo checklist to be completed in order to provide us with visual records to refer back to once we were out of the field. This photo checklist called for pictures of the shop, the solar panel and system, the entrepreneur, surrounding area, possible employees, customers, and other shop products. Both the area evaluation and photo checklist were formatted like a survey in order to take quick notes of the surroundings and expedite the site visits. This offered essential information on possible discrepancies within different shops' interview and survey results.

CHAPTER 5: ANALYSIS AND RESULTS

5.1 Shop Visits and Observations

During the course of our research we spoke with all ten entrepreneurs and visited the eight shops currently in operation. At each shop, we conducted an interview with the entrepreneur and conducted 5-10 surveys in the surrounding communities. The two entrepreneurs without fully operational shops were informally interviewed to determine what course of action could be taken to revive the shop.

As part of our pre-field work, we visited the Havanna 1 and Havanna 2 shops due to their close proximity to the DRFN. Both shops enabled us to refine our methodology by testing and revising our interview and survey questions. We found only small problems with our questionnaires including wording and sequence. Our liaisons informed us that some questions would be considered too direct or too personal to ask at the beginning of the interview. Certain questions needed to be worded properly in order to better convey our intentions and receive the necessary information. Choice of wording usually did not pose a large problem, since the majority of interviews were done through translation. Often, the questions could be translated in various ways to suit the given community and gain the proper information. The visits at these two shops allowed us to refine our questions and practice the interview process to make it more expedient at other shops.

We determined the monthly and total income from the solar system services generated by each shop. Appendix F includes monthly totals from each shop and Appendix G includes the totals from each shop over the six month period separated by each service, cell charging, haircutting, and other charging. This data was helpful in comparing the economic success of each shop and influential factors on this success.

We compiled all data into separate Excel spreadsheets for community surveys, entrepreneur interviews, and area evaluations. To summarize this extensive data, we produced Entrepreneur Profiles, which can be seen in Appendix A. These profiles give a shop description, entrepreneur description, financial summary, market analysis, technical problems, and anomalies at each shop. Each profile offers a quick look at the shop as a whole and incorporates data from each of our data collection methods. In order to offer a clearer picture of the area at each shop, an area evaluation summary was also produced and can be found in Appendix E. This area evaluation includes a

small description of the area and the shop structure and quality along with a picture. The entrepreneur profiles and the area evaluation summary give a descriptive overview of every shop.

5.1.1 Havanna 2

Our first shop visit was at Havanna 2, operated by Ms. Justina Paulus out of her home. This shop has the lowest recorded sales of all ten shops, but has had a relatively steady increase in profit since its implementation. Ms. Paulus did not have what would be considered an established shop before receiving the solar system. She ran a small business selling homemade bread at the local market. Currently, Ms. Paulus offers cell phone charging services and haircutting; however, haircutting is only offered occasionally because she is not confident about her own ability and typically has her son perform the service when he is available. Since her son does not live at home and has an outside occupation, he is only available on certain weekends. The two portable LED lanterns were sold; unfortunately, those who purchased them go to a nearby grid for charging. While there is a market for other charging services, she has not branched out to additional services because she decided to adhere to what the DRFN explicitly explained to the entrepreneurs.

Ms. Paulus' advertising and expansion has been limited due to fear of vandalism or theft of the system. She does not want to spread word past her immediate neighbors; however, during customer interviews, we found that even within her immediate vicinity, there was very little knowledge of the existence of her shop. Her shop has more of a challenge than other shops due to the close proximity to a grid connection. While she may be struggling, she does not turn away customers if they do not have sufficient money. Her typical monthly income is around N$130. She has been able to save between N$75-N$100 each month by operating the system alone.

5.1.2 Havanna 1

The Havanna 1 shop is an established shebeen run by Mr. Venasius Amukwa in the informal settlement of Havanna. While it is not connected to a grid, the shop is located across the road from a cell phone tower and power lines can be seen in the nearby vicinity. The shop is centrally located in Havanna next to a main road with a steady amount of pedestrians and cars. Although Mr. Amukwa received the current

solar system in October of 2009, he had already been operating a shop with cell phone charging service. The current system was simply an improvement over the previous system with more capacity allowing additional charging. Moreover, his shebeen sells other grocery products and alcohol.

As a result of his use of the previous solar system, Mr. Amukwa now advertises for similar systems in his shop. Currently, Mr. Amukwa does not operate the shop during most business days due to his outside occupation with Terrasol, one of the solar system providers. In his absence, Mr. Amukwa's brother runs the shop, but can only be there for part of the day and open the shop around noon. Even with reduced hours, Mr. Amukwa's shop is the second best performer with an income of approximately N$800 per month from solar system services alone.

5.1.3 Ombuojo-Okakarara

The Ombuojo shop, approximately 15 km outside of Okakarara, is operated by Ms. Claudia Kaangunde out of her home. She has permanently attached solar panels on her roof, and offers charging services whenever there is someone available at home to provide them. As her husband assists her in this endeavor, there is rarely a time period when no one is at home. She consistently offers cell charging, and on cloudy days or times when the system runs out of power, she uses her car battery to charge cell phones. While she offers both lantern charging and haircutting, these services have rarely been utilized: we recorded only five people charging lanterns and three coming in for haircutting. The largest discrepancy to note in the data arose from her haircutting. Most of the customers interviewed claimed to have their haircut from Ms. Kaangunde once a month whereas she states in her interview and records that it only occurred three times overall within the six month period.

Currently, she keeps records for herself in a personal book and transfers the relevant information into the DRFN provided forms. During the visit, we procured Ms. Kaangunde's book to compare some of her original records with that on the DRFN forms as there was some confusion and discrepancies with the record keeping. Ms. Kaangunde has been able to earn on average approximately N$200 per month using the solar system and has expanded her business to sell recharge vouchers, cell phone covers, and meat.

While most people find Ms. Kaangunde both helpful and friendly, some community members appear to be jealous of the system. One customer interviewed expressed the opinion that, although they have to use the system, they would prefer not to go to her shop. There are three other locations within the area that use 12V batteries to charge phones, and these other shops discourage people from going to Ms. Kaangunde's shop. Her customers still use her shop because of her superior "customer care".

5.1.4 Tsumkwe

Currently the shop in Tsumkwe is not operational. The proprietor of the shop, Mr. Mukonda Lucas Musongo, operated the shop during December and part of January mainly profiting from haircutting services. He received a job in Omatako during this period and had to leave Tsumkwe for extended time intervals. Although he attempted to stay open by having his brother operate the shop, he was not confident that proper records were being kept and subsequently returned the system to the DRFN.

In our discussion with Mr. Musongo, we attempted to find a way for him to continue the shop while also keeping his job in Omatako. While he previously had a poor experience with his brother conducting shop operations, Mr. Musongo was confident that he could teach both his brother and his wife how to follow proper business practices and run the shop during his absence. As long as Mr. Musongo could visit the shop every two weeks and teach proper record keeping to his family, the DRFN agreed to return the system to his care. This was also allowed because the system could be returned at any time to the DRFN project office in Tsumkwe.

5.1.5 Gam

The shop in the village of Gam is the overall best performing shop in terms of earnings generation. The focus of our interviews in Gam was to determine what factors influenced Gam's extreme success. Mr. Alex Kandetu manages the shop; he also has an outside occupation as a school teacher. Due to this outside occupation, he hired employees for daily shop operations, one employee for each service of cell phone charging, haircutting, and selling of other products. These employees receive a small salary every month and the haircutter sleeps in the shop for safety reasons.

Gam is an un-electrified village located very remotely, approximately 450 km from the nearest established grid connection. Although two other shops offered cell phone charging before Mr. Kandetu began running his charging business, they have since stopped offering these services. There is also a government building with a diesel generator and an electric charging outlet, but it is not open for public use. For the majority of those living in Gam, Mr. Kandetu's shop is the only alternative to traveling approximately 100km to Tsumkwe in order to receive energy services.

Mr. Kandetu invests a great deal of effort into his current shop. He built the current shop structure from money he had saved because he received the solar system. He also plans to expand by adding another room devoted to haircutting services. There have been problems with vandals stealing shop products and cutting system wires, all of which he had to replace. The shop earns on average about N$2,000 monthly, but Mr. Kandetu retains these earnings and reinvests most of the money in the shop every month, resulting in very little net profit for himself.

5.1.6 Koro Village - Rundu

The shop within Koro village, situated 18 km outside of Rundu is operated by Mr. Malyatta P. B. Chanel and is the third best performer of all the shops. While Mr. Chanel offers cell phone charging, haircutting, and lantern charging, he also charges other items brought into the shop including radios, 12V batteries, and several portable DVD players. The system does not have the proper connections to charge a 12V battery; therefore Mr. Chanel creatively modified his system by connecting an AC-DC “mini-charger” to the inverter to allow for this. This allows charging of the 12V battery. He has also accounted for other drawbacks in the system. For instance whenever customers need to bring in their own chargers, he lowers the charging price from N$6.50 to N$5.00 for the inconvenience.

Mr. Chanel keeps a very lively shebeen, often staying open until midnight on the weekends because of the lights connected to the system. He holds braais (barbeques) for customers at his shebeen as a method of advertisement. People come in for the food and drinks then see the system and ask him questions about it. His shop is easily recognized with a sign outside indicating prices and services offered. Mr. Chanel has prior experience running a shebeen. Unfortunately, everything was stolen from him and

he has only been able to restart his business by reinvesting profits from the solar system.

The system may not be able to remain in Koro however. Recently, the government had extended grid electricity to the school in the village and all houses within 500 meters of the school. Mr. Chanel's shop is within this area and he will begin receiving grid electricity in May. He would like to keep the system as solar energy is free and he will have to pay for grid electricity. Here the DRFN must determine if the system should stay within an electrified area. Typically, Mr. Chanel's shop makes N$530 per month.

5.1.7 Enyana

Mr. David Shikojeni manages the shop in Enyana, located 15 km from the nearest grid connection. While Mr. Shikojeni owns the shop, he does not conduct day-to-day operations due to his outside occupation as an insurance broker. An employee runs the shop, receives 30% of the profit, and sleeps there overnight to deter vandalism or theft. His shop is an established shebeen in the center of the community with a pool table and a refrigerator. Most customers approve of Mr. Shikojeni's pricing schemes and often walk large distances to frequent his shop. His record keeping follows the DRFN model exactly as he keeps track of names, cell phone types, cost, and daily totals. This also assists with possible theft or mistaken phones since customers can determine which phone belongs to whom from the records. Even with steady income of about N$400 per month in the shop, Mr. Shikojeni thinks he can do better especially visiting the shop more frequently; he currently only comes once a week or so.

5.1.8 Engela

The state of Engela's shop was unknown to the DRFN because the proprietor, Matheus Haimbodi, had not contacted the DRFN on a regular basis or sent in his financial records for any of the months of operation. Due to his incompliance with the DRFN contract, our intent was to remove the system from Engela during our field work. Upon arrival at Haimbodi's home, where he keeps the system and discussion with him, our project liaison Abraham Hangula determined that another trial of the system in Engela was necessary. Mr. Haimbodi was allowed to keep the system for two more months under certain conditions. He must move the system to his shebeen more

centrally located in town, he must send monthly records to the DRFN, and he must advertise the system within the community. If he adheres to these three conditions, he will be allowed to retain the system and be given the same option as all the other entrepreneurs to purchase the system.

5.1.9 Omboto

The shop in Omboto has certain advantages within the community. Mr. Paulus Antindi is the chief of the village and all customers say he is the preferred choice for cell phone charging over other shops with energy services in the area. Mr. Antindi has an outside occupation as a school principal and his wife is a teacher at the village school. This allows the family to have outside income and also offers a means of advertising. They inform the schoolchildren about the shop and have them tell their parents about it. Mr. Antindi also used the town meeting to inform the village about his solar system.

He displayed creative ideas for uses of the solar system. He thought of offering typing services using a laptop connected to the system; however, when he attempted to operated his personal computer through the system, it drained the battery in approximately an hour. He would like to see more capacity in the system to offer this type of service.

While Mr. Antindi offers energy services out of his home, he does have an established shebeen in town. He keeps the solar system at home for safety reasons, but will be moving it in the near future when he can find someone to stay overnight in the shop. Currently, he has his wife and nanny at home for charging services when he is not available and an employee at the shop. He enjoys having the system at home, however, as it improves the quality of life for him and his family. He would like the purchase the system because of this. Mr. Antindi's average monthly income from the solar system is N$260.

5.1.10 Karetes - Khorixas

The most positive community response of the system was received in Karetes village around 20 km outside of Khorixas. The shop is operated by Ms. Magdalena Nerongo out of her home, which is always open for customers. Every community member surveyed said the system was a good thing and the addition of another shop in the area was not necessary, although they all would like their own solar system for

personal use. Ms. Nerongo was also very pleased with the system; however, she was under the false impression that all the income generated using the system (approximately N$225 a month) belonged to the DRFN and had to be returned after the six month period. She believed the two portable LED lights that came with the system were also property of the DRFN and could not be given away. Instead of selling these lights, she rented them out for a small fee. None of the community members were jealous that Magdalena received the system because she was not making a profit. Some confusion on the part of Ms. Nerongo may have arisen because she did not attend the DRFN's initial training sessions, but sent her nephew instead.

5.2 Shop Similarities

After visiting the energy shops, similar traits surfaced across almost all of the entrepreneurs and their businesses. Although almost all of the shop owners attended the same training session sponsored by the DRFN, their business practices were not consistent. Communication between the shops did not occur due to their remote locations. Unless otherwise noted, our general results exclude the Tsumkwe and Engela shops as they were not operational and proved nearly incomparable outliers to the other shops. The Tsumkwe shop only operated for one full month and part of another, while the Engela shop did not provide any financial data, rendering a meaningful business analysis impossible. Neither shop owner was formally interviewed as most of our questions did not apply.

As each shop owner was given nearly free reign for business expansion, one key factor noted at each shop was the offerings of other non-solar products and services. These included items that the DRFN's system did not directly provide. Strictly speaking, every shop offered something other than solar services, although major differences were noted. The entrepreneurs in Havanna 1, Gam, Rundu, and Enyana all had shops sectioned off or completely separate from their living space that consistently provided other products such as snacks, beverages, oil, sugar, and canned goods. Other shop owners used different practices. For example, the shop owner in Havanna 2 sold bread at the local market baked with a solar cooker box from the DRFN. This product was not offered at the same location as her solar charging system. In Omboto, the owner had a permanent structure built for a shebeen selling cold drinks (including alcoholic beverages), crackers, tableware and other products. However, for security reasons, the

owner ran the solar charging system out of his home, separating the two sets of products and services. The shop in Karetes did sell other products bought from Grootfontein, but her infrequent travel to that town caused her shop's products to be stocked sporadically and inconsistently. In Ombuojo, the owner sold cloth cell phone cases and service provider access time ("minutes"). However, the level at which she offered these other products on was significantly lower than those encountered in the first four shops mentioned above. Figure 6 shows how the consistent selling of other products in the shop influences the income generated through charging services.

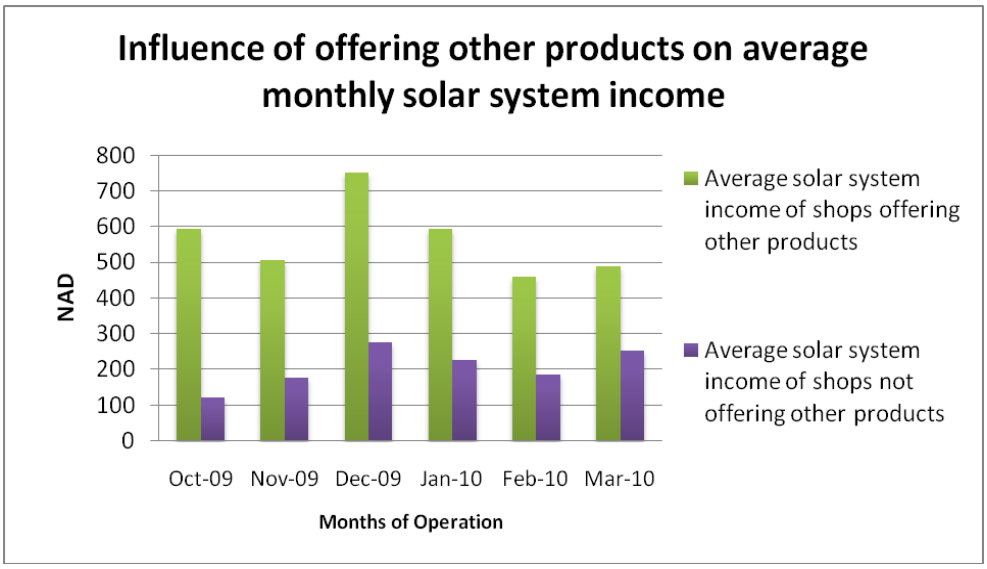


Figure 6: Influence of offering other products in the shop on the average monthly income generated only by the solar system

The average monthly totals of the income only generated by the solar system at the shops in Havanna 1, Koro, and Enyana are labeled in green as they consistently offer other products at their shops. The average monthly totals of the income only generated by the solar system at the shops in Havanna 2, Omboto, Karetes, and Ombuojo are in the violet as they do not consistently offer other products in their shops. Gam, Engela and Tsumkwe have been removed from Figure 6 as they are outliers and skew the data. It can be speculated that offering other products in the shop increases the profits generated solely by the solar system. Each month, the shops that offer other products have solar system income totals more than double that of shops that do not offer other products.

Each system's proximity to the owner's residence was noted. Only three shops, Gam, Rundu, and Enyana operated the solar business from a location separated from where they slept. Gam and Enyana had separate buildings located in their respective

village's business centers, while the owner in Rundu dedicated a building in his homestead to the system and his other business. On the other extreme, every other owner housed the system in the same place where they slept. Here again, differences should be noted. For instance, the entrepreneur of Havanna 1 clearly separated his living space from his business space. Although he slept in the same building, this area would only be seen or be accessible by traversing through a door to the back of the shop, where customers were not allowed. Figure 7 below shows how the shop income can be influenced by its separation from the entrepreneur's home.

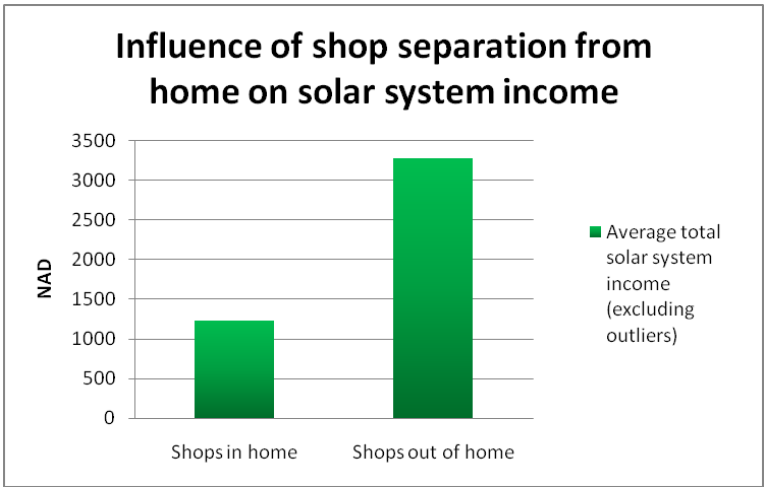


Figure 7: Influence of shop separation from home on average total solar system income

Shops in home include Havanna 2, Ombuojo, Karetes, and Omboto while shops out of home include Havanna 1, Koro village, and Enyana. Gam, Engela and Tsumkwe are considered outliers and have been removed. Shops in home have almost three times lower earnings than shops out of home.

The shops are located in various off-grid villages around the northern part of Namibia. No specific distance was set as a location requirement when selecting these villages but these distances were recorded. The closest shops to grid electricity were Havanna 1 and Havanna 2 within 5km from the nearest connection. The shops near Okakarara, Omboto, and Khorixas are within 5-15km of a grid connection. Rundu and Enyana both set up their shops from 15-30km to the nearest connection and the people in Gam would have to travel approximately 400km to reach grid electricity. Aside from Gam, no shops were located greater than 30km from the grid. These distances are shown in Figure 8 below with the average total solar system income of shops within these distances.

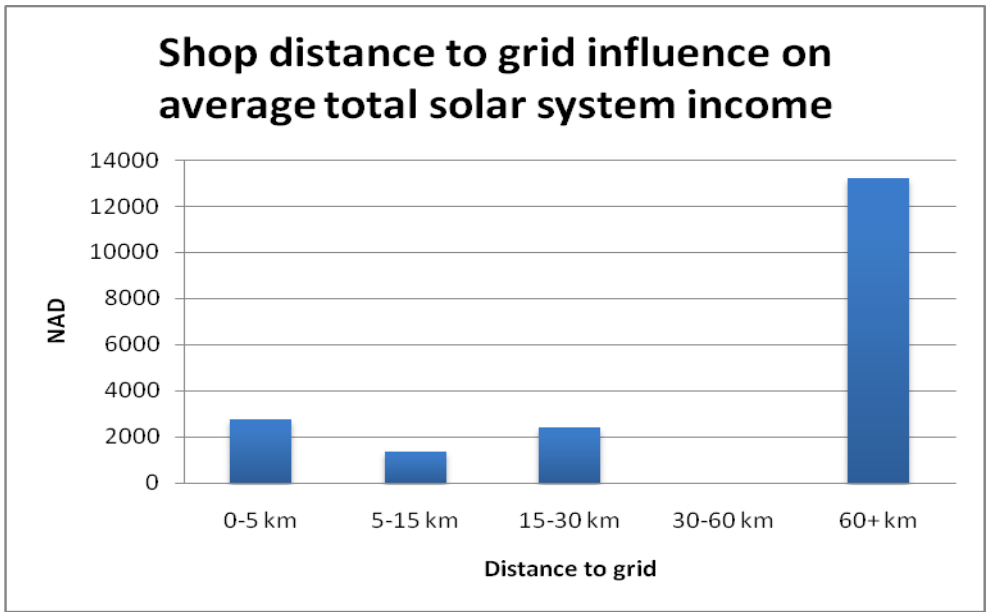


Figure 8: Influence of shop distance to established grid connection on average total solar system income

The shop greater than 60km from the nearest grid connection performed much better than shops within 30km of a grid connection. Those shops within 0-5km of a grid connection have an extremely large population density surrounding them and, thus, a larger market which would account for their income similar to shops 15-30km from a grid connection. Shops within 0-5km do not have the same market security of shops larger distances away from the grid. It is clear that greater than 60km from a grid connection assists shop performance and allows for greater solar system income.

When selecting which entrepreneurs would be a part of the DRFN's pilot program, a recruitment analysis was performed. Potential shop owners were given a survey detailing their backgrounds and business experience. In particular, the owners were asked what sort of prior business training, if any, they had received. Three options were given: none, basic skills, and management skills. Basic skills training would include classes such as marketing, accounting, or pricing while management skills include advance managerial topics such as human resource management or business practices. Out of the eight entrepreneurs with established shops, Ombuojo, Khorixas, Engela and Havanna 2 reported having no training, Enyana, Koro, and Havanna 1 reported basic skills training, and Gam reported having management skills training. The owner in Omboto and Tsumkwe did not complete a recruitment survey. In Figure 9 below, the graph shows the average total solar system income of shops with no business training, basic skills training, and management skills training.

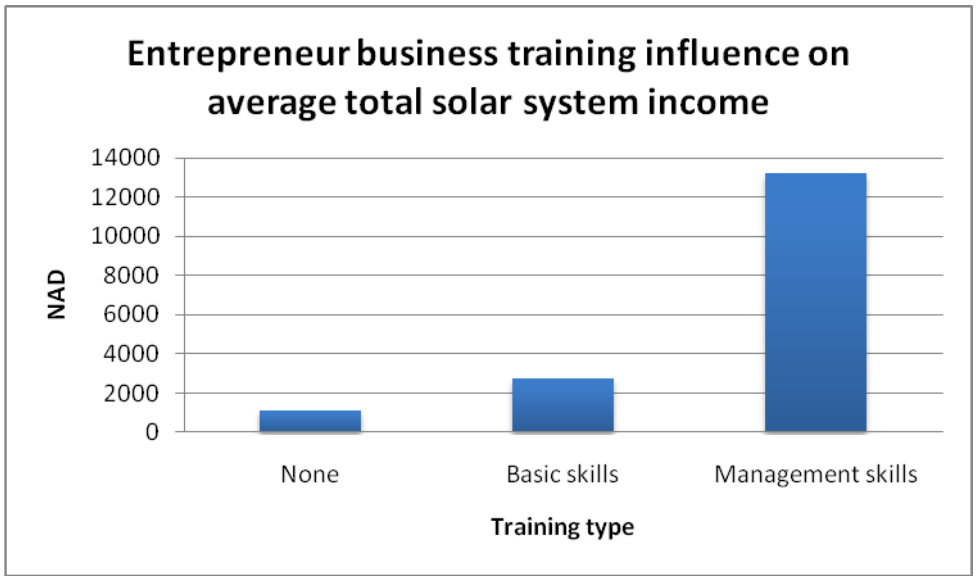


Figure 9: Influence of business training on shop average total solar system income

The graph shows that shops with more business training enjoy a higher income from the solar system. The outliers Engela and Tsumkwe have been removed while Gam cannot be removed as he is the only shop entrepreneur to receive business training in management skills.

Six of the eight established shops experienced an increase in business between the months of November and December with four shops experiencing their highest earnings within the month of December. (See Appendix F for monthly totals of solar system income.) Although not reported at all shops, three of these eight entrepreneurs cited December being a holiday month as the reason for these increases. According to these entrepreneurs, those with family in the village may work or attend school in other nearby towns and come home during their time off. During this holiday time, the shop owner's available customer base is increased.

Every entrepreneur offered cell phone charging during the six-month evaluation period recorded so far. This is the main service offered by the solar system as the system comes with a set of ten assorted DC cell phone chargers and ten DC outlets. The shops in Gam, Rundu, and Karetes, offered haircutting consistently (recorded haircutting earnings for at least five of the six months) and Havanna 2 and Ombuojo offered haircutting earnings for at least one month. Other charging services (any charging excluding cell phones, i.e. lanterns and radios) were offered at five of the eight shops, although in a sporadic manner and totaling only 2% of the shops' total earnings.

Stated reasons for not offering certain energy services varied. The three shops that never offered haircutting, Havanna 1, Omboto, and Enyana, reported that they would like to offer the service but needed to find a trustworthy and capable employee to begin this activity. Omboto also does not have enough space within the owner's home and will expand to offer haircutting once the system has been moved to his shebeen. The shop owner at Ombuojo provided haircutting services herself, but did not feel comfortable enough in her abilities to continue the service. In Havanna 2, the entrepreneur's son offers haircutting but only while he was home. As this is not often, the service is used infrequently.

Reported difficulties with the system include limited power during cloudy days, broken DC outlets, a lack of correct cell phone chargers, and a blown fuse. Every shop except for Omboto and Karetes observed decreased battery capacity during cloudy days. Only Havanna 1 reported turning customers away during cloudy days, although others lost all battery charge after approximately two days. Ombuojo and Gam both solved the drained battery problem by charging their customers' phones with their cars. Broken or faulty DC outlets were reported at Gam and Enyana but normal business still occurred; both entrepreneurs used the AC outlets for charging when necessary. Very few issues were related to problems with the solar system. Two blown fuses in the inverters were caused by plugging in incorrect items which the system is not able to handle. These two systems were fixed easily by replacing the fuse in Windhoek.

Advertisement strategies varied between shops but all entrepreneurs agreed word of mouth played a role in increasing the popularity of their business. The entrepreneurs from Gam, Havanna 1, Havanna 2, Rundu, Enyana, decided to place signs in various locations ranging from in front of their shop to at the local school. Only Gam paid for the signs (N$10) while the rest made their own free of charge. All shops, except Havanna 1, reported an increase in customers after placing their signs. More innovative advertisement strategies included arranging publicity braais (barbeques) at Rundu, discounts for regular customers at Rundu and Omboto, and fliers at Enyana. These ideas reportedly have increased the shop owners' customer base. According to the customers, word of mouth was the most frequent method of advertisement. As seen in Figure 10 below, 70% of respondents said word of mouth was used, while 18% saw the shop or the solar system and only 8% learned about the shop through signage.

Figure 10: Percent of respondents that heard about the shop through certain methods of advertisement

Signage is an under-utilized method that can increase a shops' customer base. Having people see the system also is a useful method of advertisement.

Some entrepreneurs employed other people from their village to help operate their energy shop. We noted employees in Gam, Enyana, Omboto, and Havanna 1, although what constitutes an employee across those four shops varies. Gam and Enyana both pay employees that are not part of their respective families. In Havanna 1, the shop owner pays his brother N$350 a month to run the shop, while at Omboto, the entrepreneur's wife and nanny run the system while he is away without any compensation. The shop in Tsumkwe will also be operated by the owner's family since the owner cannot be at the shop for weeks at a time. It is not known whether or not they will receive compensation.

Business practices for the shops are not constant or concrete. All shops allow their customers to pay before and pay afterward. Some shops allow regular customers to charge on credit, but Ombuojo and Omboto have had customers default on this credit. Usually the problem is fixed by confronting the customer. The Karetes shop allows customers to charge throughout the month and collects payment at the end of the month when the villagers have money. Issuing receipts is also a common practice and allows the entrepreneurs an additional security measure against phone theft as names and phone types are written on receipts. In Havanna 1, phones will not be returned to the customer unless they have their receipt.

CHAPTER 6: CONCLUSIONS

Our research concluded that energy shops provide a viable and sustainable alternative to relying solely on grid electricity in Namibia. In this chapter, we will summarize the key discoveries that allowed us to arrive at this positive conclusion. We will also present recommendations for the DRFN to apply to future energy shop endeavors.

6.1 Economic Viability of Individual Shops

From our data analysis and first hand observations and correspondence with the entrepreneurs, we feel that each shop has the potential to be economically viable individually. We define economic viability as the entrepreneur's ability to repay the N$12,000 system cost plus a 5% fixed yearly interest rate in five years or less. To repay the system's cost in the required five year time frame, an entrepreneur would have to pay approximately N$250 monthly. Although all ten shops did not generate this amount every month, we feel that this is a realistic and attainable goal for every shop. Those shops that were underperforming in this initial six month period were given advice on how to improve their business. We feel reasonably confident that with these improvements in a few additional months these shops will have the ability to perform at a satisfactory level. Additionally, the recommendations detailed in Chapter 7, if heeded, will most likely prevent the establishment of shops that underperform.

6.2 Social Implications

In addition to the economical viability of the shops, we investigated the social implications of installing these shops in rural areas. Overall, the surrounding community was in favor of the shop. The majority of community members surveyed were customers of the shop and enjoyed supporting its operation. In many cases, however, entrepreneurs reported they noticed members of the community were jealous. They think this is due to the fact that they received a solar system for free and were making a profit at the expense of the community. If the project is extended by the DRFN, the system should be purchased originally on a loan basis. Hopefully, this will help eliminate jealousy in the community. Apart from envy, feedback from the community was generally very positive. Most community members indicated that they

prefer supporting the DRFN solar shop in their area rather than other shops, and that the shop owner was friendly, helpful, and knowledgeable in regards to the solar system.

Moreover, the energy shops provide business opportunities in areas where employment is scarce. It may seem that only one household (the shop owner's) is fully benefiting from the solar system, but in certain cases, a single shop can employ up to four individuals. These four individuals are in turn able to cycle the money back into their households and the community at large, thus improving the lives of many community members.

6.3 Feasibility of Project on a Larger Scale

The initial plan set forth by the DRFN for solar-powered energy shops is small-scale and has a time frame for only one year. We concluded that even at this early stage there is sufficient evidence suggesting that the energy shop concept should be expanded and implemented on a larger scale beyond the initial program constraints. Three-quarters of the shops in the pilot program were performing sufficiently well to pay back the system in five years or less. With small changes to the selection process, system training, and shop operation, as well as record keeping requirements, we feel confident that all of the shops can perform at this level. With the help of the Solar Revolving Fund, the DRFN would be able to install systems on a "rolling" basis: once the cost of one shop is recovered, another system can be purchased with those funds and another shop is launched in a designated location. This process could be done with several shops at once since the loan system is through an external provider and would cause minimal financial strain on the DRFN. Such a system would allow the continuous establishment of multiple shops with minimal financial risk. If a shop were to default on their loan, the solar system would be removed and placed in a new location.

If the DRFN would like to monitor shop deployment through yearly visits to the energy shops, it can do so efficiently. Our team was able to visit ten entrepreneurs in less than two weeks. If the shops were installed on a rolling basis, this would further ease site visits since each additional shop would reach its yearly milestones at a different time.

While the DRFN began the energy shops with this pilot program, it may not have the finances or man power to continue the program once it reaches a sufficiently large scale. Through a partnership with the Ministry of Mines and Energy and their energy

shop rollout program, the Off-Grid Energisation Master Plan, shops can be selected and implemented by the DRFN and maintained and upgraded by the MME. The large scale of the OGEMP and the funding that can be provided by the MME offers a means to expand the program beyond its original concept. Additionally, the Solar Revolving Fund has recently undergone changes in administration and currently is maintained by the MME. Once the DRFN has concluded its part of the energy shop program, it can be handed over fully to the MME as originally proposed in the OGEMP.

CHAPTER 7: RECOMMENDATIONS

As a result of our data collection and analysis, we have developed a set of recommendations for the continuation and replication of 'Business Opportunities with Solar Energy in Un-Electrified Areas'. These recommendations can be used both by the DRFN and the Ministry of Mines and Energy to aid their energy alternative initiatives.

7.1 Entrepreneur and Location Selection

We recommend that entrepreneurs be required to distribute EPOGES (energy profiling survey) to their community as part of the application process.

The completion of this market assessment survey will determine if energy shop services can be useful in a potential area while also showing the perspective entrepreneurs' interest level and dedication to the reception of a solar system. If the entrepreneur actively distributes the survey and returns the results to the DRFN, it is likely they will operate their shop with similar efficiency. Conversely, it is unlikely that someone who does not distribute the survey and return the results to the DRFN will adhere to certain contract requirements, such as reporting monthly financial income. Additionally, results of the survey can be used to determine if there is in fact a need for an energy shop in a particular community.

We recommend choosing entrepreneurs that have received prior business education.

Analysis of the financial records revealed that entrepreneurs who had previous business education performed significantly better than those entrepreneurs who did not. For this reason, entrepreneur selection should focus on individuals who have attended at least some formal classes regarding business and/or management practices.

We recommend that preference be given to those shops located farthest from the closest grid connection.

The financial records showed that shop revenue increased with distance from the closest grid connection. Competition arises when a settlement is located too close to a grid connection. Shops placed in remote locations will have a larger regular customer base than those shops in peri-urban areas, resulting in greater revenue generation.

7.2 System Training

We recommend that attendance to the system training at the DRFN be mandatory for all entrepreneurs.

Three of the ten entrepreneurs did not attend the system training in 2009. One entrepreneur sent a substitute in her place and the two others received the system late. These three were not as educated in system operations and record keeping as the rest of the entrepreneurs. This led to a few misunderstandings regarding financial record keeping and understanding system capabilities, lowering their revenue. This problem could be rectified through mandatory attendance.

We recommend that the training include the technical aspects of the solar system.

Knowledge of technical specifics would aid the entrepreneur in day-to-day operation of the solar system. The entrepreneur should be aware that the solar panel is 80 watts and that the standard 12-volt battery has a storage capacity of 105 ampere hours (Ah). As a result, it will take approximately 16 hours to fully charge the battery to its maximum energy level of 1260 Wh. However, the batteries provided with the solar system should only be discharged by 80% of their maximum energy or they will be damaged. Adding up the watt ratings of similar appliances to be charged and dividing the total by the maximum battery energy level yields the appliances' time of operation. He or she should know that DC charging is at low voltages, typically 9-12 volts, while AC charging is at 220 volts. This knowledge will help prevent improper and damaging use of the system.

We recommend that the training clarify the solar system's capabilities.

Entrepreneurs were occasionally forced to turn away customers with other charging needs because the system's capabilities were not explicitly explained at the training. It should be known to the entrepreneurs that the system is capable of charging almost any electronic device (via the 220 volt AC power strip) and that charging services are not limited to cell phones and lanterns.

We recommend that the DRFN discuss options for system expansion with the entrepreneurs.

A number of the shops reported occasionally not having sufficient energy for the demand of the customers, especially on cloudy days. The DRFN should explain how the

system can be expanded for extra capacity, for instance, by connecting an additional solar panel and/or battery. The solar panel appears to provide sufficient electricity to charge a single battery and provide charging services. If an entrepreneur installed two solar panels, more services would become possible. An additional battery for storage would render cloudy days less of a concern.

We recommend that haircutting training be part of the system training.

The financial records show that when a shop is offering haircutting services, which is a large revenue generator itself, cell phone charging revenue also increases. A large number of the shops did not offer haircutting services because the entrepreneur did not feel confident in his or her ability to do so. If all of the entrepreneurs were trained on how to use the hairclipper provided to them, the shops would likely perform better as a whole.

7.3 Shop Operation

We recommend that the entrepreneurs be required to place and operate the solar system in a location that is separate from their home.

Analysis of the financial records shows that systems generate significantly more revenue if they are placed in locations that are separate from the entrepreneur's home or living quarters. Additionally, out of home systems tend to draw a larger customer base compared to systems in home. In order to provide energy services to the largest number of customers, it would be advisable for an out-of-home-shop-location clause to be included in the purchase contract.

We recommend that, in addition to charging services and products, the entrepreneur offer non-energy products.

Shops which sold non-energy products such as groceries and beverages generated significantly more revenue than shops that did not offer non-energy products. The ability to buy groceries at the same location an individual can charge their cell phone appeals to community members.

We recommend that the entrepreneurs advertise their solar business by whichever means they feel will be most effective.

Advertisement had a large impact on the success of the solar system. When the shop was not signed or the entrepreneur only told a select few individuals about the

system, the solar income generated was generally low. Entrepreneurs who advertised actively by word-of-mouth or signage showed a higher cash flow. For this reason, word-of-mouth and signage advertising should be required.

7.4 Record Keeping and Reporting

We recommend that entrepreneurs be required to record and report data on templates provided by the DRFN.

Financial records contributed substantially to the analysis of the pilot program. This task could have been made easier by streamlined record keeping. Entrepreneurs should be practically instructed on how to complete these forms as a part of their initial system training and required to use them throughout their partnership with the DRFN.

We recommend that revenue from the solar system be separated from revenue generated by selling non-energy products in the DRFN records.

A small number of the entrepreneurs reported the total revenue generated at their establishment. This made it more difficult for the DRFN to isolate the revenue was generated by the solar system it provided. If the solar system revenue is separately accounted, a subsequent financial analysis will become easier.

We recommend that the DRFN offer the entrepreneurs incentives for continued recording and reporting income generated from the solar system.

It is likely that future distribution of solar systems by the DRFN will be supported in part by the Solar Revolving Fund. If this is the case, the entrepreneurs will have no obligation to the DRFN and no reason to report their income on a monthly basis once they pay for the system. The DRFN, however, could use this information in a future, larger, macroeconomic analysis of energy shops in Namibia. For this reason, the DRFN should offer incentives such as system maintenance and technical support to those entrepreneurs who continue to report their earnings to the DRFN. It should also be communicated to the entrepreneurs that top performers will likely be promoted to a higher-level energy shop, which would offer more products and services, thereby increasing their overall earnings.

REFERENCES

Brent, A. C., & Rogers, D. E. (2010). Renewable rural electrification: Sustainability assessment of mini-hybrid off-grid technological systems in the African context. *Renewable Energy, 35*, 257-265.

Bubenzer, D. O., Bolten, D. A., Darius, D. F., Ritter, M., Waldhoff, G., Weischede, M., Lutz, S., Hecker, D. & Greif, P. (2004). Retrieved January 29, 2010, from http://www.uni-koeln.de/sfb389/e/e1/download/atlas_namibia/main_namibia_atlas.html.

Dentlinger, L. (2010). Namibia's power supply "on brink". *The Namibian.*

Desert Research Foundation of Namibia (March 2008). *REECAP 1.13: Guidelines for the Establishment of Energy Shops in Namibia*. Namibia: DRFN Energy Desk.

Desert Research Foundation of Namibia Energy Desk. (2009), Retrieved from http://www.drfn.org.na/htm/energy_desk/energy_staff.html.

Egels, Niklas (2005). CSR in Electrification of Rural Namibia. *JCC*, 18, 75-85.

The Ministry of Mines and Energy. (2006). Retrieved January 23, 2010, from http://www.mme.gov.na/.

Moses, A. (2008). Application Form. *Sustainable Energy Project Support*. 1-24.

NamPower. (2009). Retrieved January 29, 2010, Retrieved from http://www.nampower.com.na/pages/rural-electrification.asp.

Ramachandran, Vijaya. (2008). 'Power and Roads for Africa: What the United States Can Do'. The White House and the World: a Global Development Agenda for the next U.S. President. Ed. Nancy Birdsall. Washington, D.C.: *Center for Global Development* 91-120.

Rothermel, J. M., Lowell, J. M., Kendrick, R., & Frey, J. P. (2007). *Energy profiling for off-grid energization solutions* (Interactive Qualifying Project. Worcester, MA: Worcester Polytechnic Institute. Retrieved from http://www.wpi.edu/Pubs/E-project/Available/E-project-050307-071942/.

Solar Panel Power Calculator (2009). *EcoWho - Green & Sustainable, Green Directory, Articles & Search.* Web. Retrieved from http://www.ecowho.com/tools/solar_power_calculator.php.

Schultz, R., & Schumann, C. (January 2007). *Off-grid energisation master plan for Namibia final report*. Namibia: Consulting Services Africa.

Utonih, S., & Dlamini, S. (2001). *Power sector reforms, rural electrification and gender – related issues.* Minerals and Energy Policy Centre.

Wamukonya, L., & Davis, M. (1999). Socio-economic impacts of rural electrification in Namibia No. 1. University of Cape Town: Energy and Development Research Centre

Weidlich, B. (2008a). *Electricity prices to soar by 2011.* The Namibian.

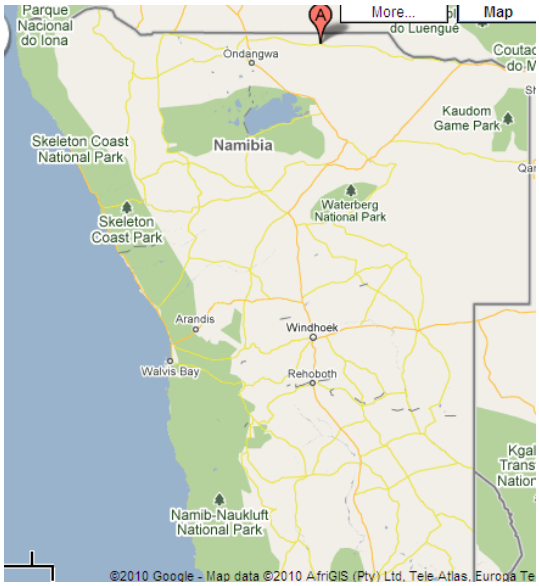
Weidlich, B. (2008b). *Namibians switch on to solar power but import costs and tariffs are hindering growth*. The Namibian.

Wolde-Rufael, Y. (2006). *Electricity consumption and economic growth: a time series experience for 17 African countries*. Energy Policy, 34, 1106-1114

Appendix A – Entrepreneur Profiles

Entrepreneur: David Shikojeni Location: Enyana-Okongo

Shop Description: The Enyana shop is located close to the Angola border, and is about 15 km from the nearest grid connection. Before the implementation of the solar system, the Enyana shop provided products such as groceries and cell phone airtime. Additionally, the shop has a pool table and a refrigerator. The shop operates daily from 7am to 10pm. On average, 5 customers visit the shop per day for cell phone charging with peak hours early to midday. The shop offers cell charging and other grocery products.



Entrepreneur Description: The entrepreneur has lived in the Okongo area for about 30 years. He has a high school education and has taken one day of basic skills training. He has 4 years of business experience and has been running his current business for 3 years. In addition to operating the

Sales Summary:

Service/Month	Oct 09	Nov 09	Dec 09	Jan 10	Feb 10	Mar 10	Total N$
Cell charging	328	388	564	428	256	432	2396
Haircutting	-	-	-	-	-	-	0
Other charging	-	-	-	-	-	-	0
Add'l services	-	-	-	-	-	-	0
Total N$	328	388	564	428	256	432	2396

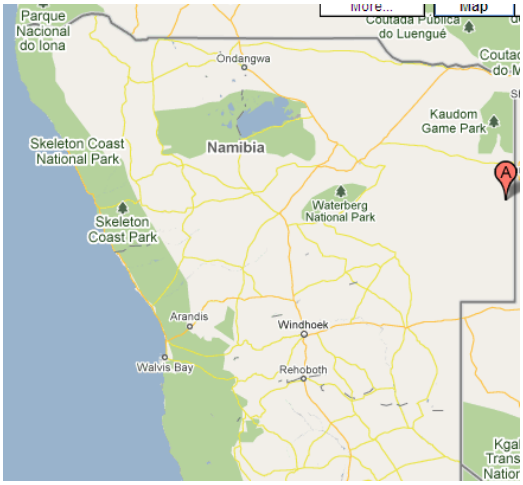
Notes: Cell phone charging services cost N$4.

Panel Efficiency:

Mr. Shikojeni is able to adequately charge all of his customer's cell phones during normal business days; however, he does report running out of power if clouds block the sun for a prolonged period of time. Since the installation of the system in his shop, he can recall two or three instances when customers have had to be turned away due to lack of power.

Market Analysis:

The shop's cell phone charging services are utilized approximately 50 to 150 times per month; the earnings should provide enough income to pay for the system within two and a half years. Currently, due to his outside occupation, he has an employee running the shop who receives 30% of all generated profit. Given the remote nature of the Enyana community, hair cutting services offered at the shop would provide an easier option than traveling to Okongo. The addition of profits from hair cutting to overall income would lower the amount of time needed to pay off the system.



Shop Description: The Gam shop is located near the border of Botswana, approximately 450 km from the nearest grid connection. The shop operates daily from 7am to 6pm, with peak hours between 11am and 3pm. On average, 20 customers visit the shop per day. The current structure for the shop was built because of the addition of the solar system. The shop offers cell phone charging, haircutting, lantern charging, and a variety of other products including groceries and cell phone accessories.

Entrepreneur Description: Mr. Kandetu has lived in the Gam area for over 12 years. He has a college education and some management skills training. He has operated a business for 10 years, and had been operating his current business for 5 years before the installation of the solar system. In addition to running the solar shop, Mr. Kandetu is a teacher. He has three employees who run the shop when he cannot be there.

Sales Summary:

Service/Month	Oct 09	Nov 09	Dec 09	Jan 10	Feb 10	Mar 10	Total N$
Cell Charging	232	1144	1244	1374	788	3135	7917
Haircutting	132	687	1351	1489	830	740	5229
Other Charging	-	20	30	10	-	10	70
Add'l Services	93	455	675	1063	-	-	2286
Total N$	457	2306	3300	3936	1618	3885	15502

Notes: Cell phone charging services cost N$4, lamp charging costs N$10, haircuts cost N$10 and beard trimming costs N$2. Additional products are sold, such as earphones, cell phone covers, cell phone batteries, and SIM cards.

Panel Efficiency:

When weather conditions are favorable, the amount of energy generated by the system is sufficient to satisfy the customers' needs. Extended periods of cloudy weather can force him to use his car battery to charge cell phones in an effort to ensure uninterrupted service for his customers.

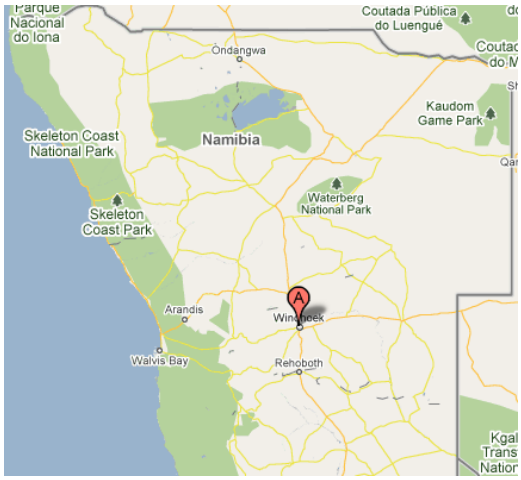
Market Analysis:

Gam is an un-electrified settlement with few energy services. Although two other shops offered cell phone charging prior to Mr. Kandetu's charging business, they have since stopped offering these services due to Mr. Kandetu's shop. There are government buildings with diesel generators where charging is free, but access is not open to the public. For the majority of those living in Gam, the shop is the only alternative to traveling approximately 100km to Tsumkwe in order to receive energy services.

Anomalies:

Gam's extremely decentralized location is likely the main cause of the high volume of customers the shop enjoys on a daily basis. It is significantly farther away from the nearest grid connection than the other 9 shops. Moreover, Mr. Kandetu also has the most business training of all the entrepreneurs.

Shop Description: Mr. Amukwa runs his energy shop with the help of his brother. He has been offering cell phone charging for several years, but switched to the DRFN's system in October 2009. He has been successful in operating the shop and keeps good records. However. they are not in the format the DRFN prefers. The shop is within close proximity to grid electricity but still remains un-electrified. The shop is now open between 12pm-10pm daily due to his outside occupation, but will be extending hours earlier to 8am-10pm. On average, during weekdays, there are 4-5 customers per day and during weekend, there are 10 customers per day.



Entrepreneur Description: Mr. Amukwa has lived in the settlement of Havanna for over nine years. Before receiving his current Solar Age System, he and his brother ran a business charging cell phones and selling other goods for five years. His shop received steady business with an increase since receiving the new system. He has had one month of formal training in basic business skills. He currently has an outside occupation working for Terrasol.

Sales Summary:

Service/Month	10/09	11/09	12/09	01/10	02/10	03/10	Total N$
Cell Charging	792	789	1164	608	704	688	4745
Haircutting	-	-	-	-	-	-	0
Other charging	-	-	-	-	-	-	0
Add'l services	-	-	-	-	-	-	0
Total N$	792	789	1164	608	704	688	4745

Notes: Cell phone charging services cost N$4.

Panel Efficiency:

When weather conditions are unfavorable, Mr. Amukwa reported having to turn cell phone charging customers away. He has considered increasing his system's capacity in order to increase his ability to conduct business.

Market Analysis:

Mr. Amukwa's shop has a high volume of customers grossing, in general, over N$700 per month. Given the profits he is making, the number of customers he receives, and the density of the community surrounding the shop, offering haircutting would increase his profits. Mr. Amukwa would like to offer haircutting, but has yet to find a skilled and reliable employee for that purpose.

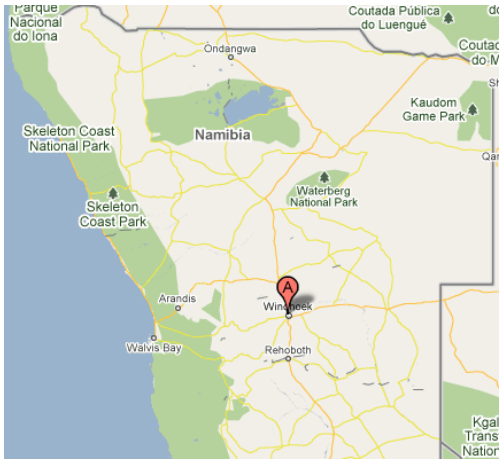
The Havanna area is extremely dense and growing at an alarming rate; however, such growth presents great opportunity for Mr. Amukwa. If he expands his shop and advertises to more people, he can take advantage of the considerable population size.

Difficulties:

The energy shop does not provide quite enough income for Mr. Amukwa and his brother. For this reason, he has procured another job working for Solar Age, and this job causes the shop to only open for use in the afternoons.

Anomalies:

Mr. Amukwa uses receipt books as a means of keeping track of phones as he gives a receipt to each charging customer. Currently, his only records are these receipt books. It would be easier for the DRFN to organize and collate his records with those from the other shops if he used the record keeping template provided by the DRFN.



Shop Description: Ms. Paulus offers charging services out of her home. There is little advertising for her shop, although she receives steady business from her neighbors. This shop only occasionally offers haircutting services, but they are relatively popular when available. The shop is open from around 7am-8pm every day except Sunday when it opens at 12pm. Between 0-5 customers come to the shop every day, with the most customers on the weekends. The shop is within a grid location but remains un-electrified.

Entrepreneur Description: Ms. Paulus is a single mother of eight who has been living in the area for over ten years. She has been running a business on her own selling bread for seven years. She has a high school education and no formal business training. She has had some business trouble in the past, but has shown a recent increase in turnover before receiving the solar system and a relatively steady increase in turnover after adding charging services.

Sales Summary:

Service/Month	10/09	11/09	12/09	01/10	02/10	03/10	Total N$
Cell Charging	52	52	100	123	141	191	659
Haircutting	-	-	37	13	14	-	64
Other charging	-	-		-	-	-	0
Add'l services	-	-	-	-	-	-	0
Total N$	52	52	137	136	155	191	723

Notes: Cell phone charging costs N$3-4 and haircutting costs N$7.

Panel Efficiency:

The solar system provides enough energy to meet the demand for cell phone charging and haircutting. Additionally, Ms. Paulus is able to light her home overnight with the surplus of energy generated throughout the day.

Market Analysis:

Located in Havanna, Ms. Paulus's shop and home are surrounded by an extremely dense cluster of houses and shacks. Increased advertising could allow her to take advantage of this clustered population by saving them the cost of a taxi into town or the time it takes to walk to a grid connection.

Profits from cell charging saw approximately a 50% increase during months when haircutting was offered. Adding this service reliably would help her business consistently increase its profits.

The existence of another energy shop in close proximity to Ms. Paulus' has not affected her profits significantly. Instead, her largest problem is a lack of advertising. Within her immediate area, there is very little knowledge of the existence of her shop. This causes her profits to be lower than that of other shops.

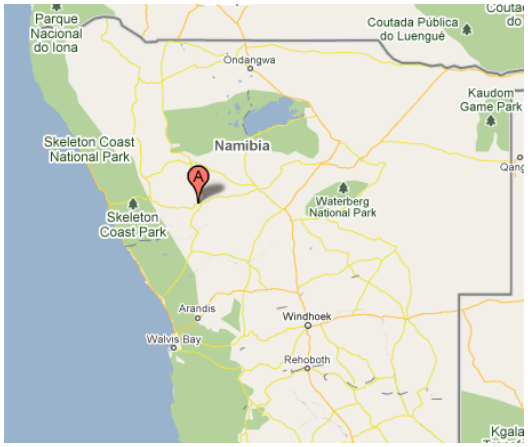
Difficulties:

The light connection on the system was damaged but Ms. Paulus has implemented a temporary solution for it. Since she operates the shop out of her home, space is limited.

Anomalies:

Ms. Paulus is one of the few shops with a solar box cooker. Her ability to bake bread without firewood may attract customers to her store; however, the cooker was not in operation or accessible when we visited the shop. She also sells the bread at a local market as opposed to out of her home.

Shop Description: The Karetes shop is located approximately 20 km from the nearest grid connection in Khorixas. Cell phone network reception in Karetes is good in certain places, and community members previously had to travel 20km to charge their batteries. The shop offers a variety of services including cell phone charging, haircutting, lamp charging, and the sale of tea and sugar. The shop is open anytime as Ms. Nerongo offers the services out of her home. On a normal day, there are around 3-5 customers, while it increases to 10-11 per day during holidays.



Entrepreneur Description: Ms. Nerongo has lived in the Karetes area for over twenty years. She has a high school education but no formal business training. Additionally, she has had five years of experience in entrepreneurship.

Sales Summary:

Service/Month	10/09	11/09	12/09	01/10	02/10	03/10	Total N$
Cell Charging	48	74	489	186	90	183	1070
Haircutting	36	28	20	-	-	-	84
Other charging	30	30	60	60	-	20	200
Add'l services	65	227	830	420	-	290	1832
Total N$	179	359	1399	666	90	493	3186

Notes: Cell phone charging cost N$3-4, lamp charging costs N$4, haircutting cost N$6, tea costs N$3, and sugar costs N$9.

Panel Efficiency:

Ms. Nerongo's system provides enough electricity to serve all of her customers. It also allows her to use electric lights throughout the night instead of candles.

Market Analysis:

Ms Nerongo's village Karetes is home to a considerable amount of cattle farmers who do not have a steady income. According to Magdalena, the people do have enough money to pay for the services her shop offers but she generally waits to collect payment until the end of the month. This practice allows customers who do not have money every day to still charge their cell phones or get their hair cut.

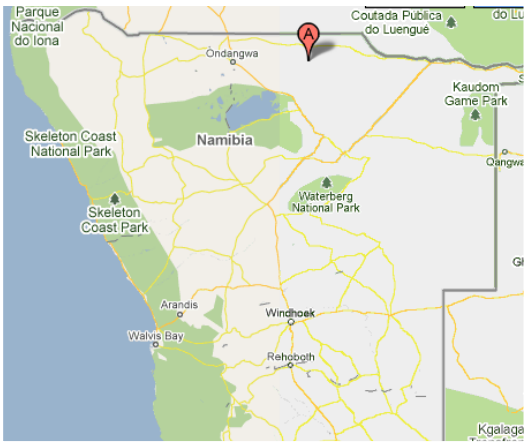
Though the same services are available in Khorixas approximately 20km from the town, the people of Karetes are generally busy tending their cattle and do not have time to travel. Additionally, a taxi can cost N$20, adding to the cost of a charge in Khorixas. Located in Karetes, Ms. Nerongo's shop provides her village's people with a cheaper and more accessible option.

Her customers' farming responsibilities generally require taking cattle out to graze from the morning to the afternoon. This means she sees the most customers during the morning before they take their cattle to the fields. To provide for these customers, Ms. Nerongo and her husband ensure that someone is always with the system.

Anomalies:

Ms. Nergongo did not attend the training provided by the DRFN before receiving the system but sent her nephew instead. As a result of this, she believed all the profits from the system and all the products associated with the system were property of the DRFN and had to be returned at the end of the six month period. She rented out the portable LED lanterns instead of selling them and paid herself for charging of personal cell phones. She has now been informed that she may keep all the profits from the system and sell the portable LED lanterns if she chooses.

Shop Description: The Omboto shop is located in northern Namibia. Though the owner runs a successful business already, the system is located in the shop owner's home for security reasons. Charging services can be obtained at any time as there is always someone at home. On a good day, there will be maybe 10 customers for charging with peak hours in the late afternoon to evening.



Entrepreneur Description: There is no recruitment evaluation available for Mr. Antindi and no previous education and business experience is known. Currently, he is the village chief and well respected within his community. He also runs a shebeen in the center of the village and has an outside occupation as a school principal.

Sales Summary:

Service/Month	10/09	11/09	12/09	01/10	02/10	03/10	Total N$
Cell Charging	144	198	177	288	279	420	1506
Haircutting	-	-	-	-	-	-	0
Other charging	8	-	-	25	30	-	63
Add'l services	39	42	46	60	56	-	243
Total N$	191	240	223	373	365	420	1812

Notes: Cell phone charging costs N$3, lamp charging costs N$4, and radio use costs N$2.

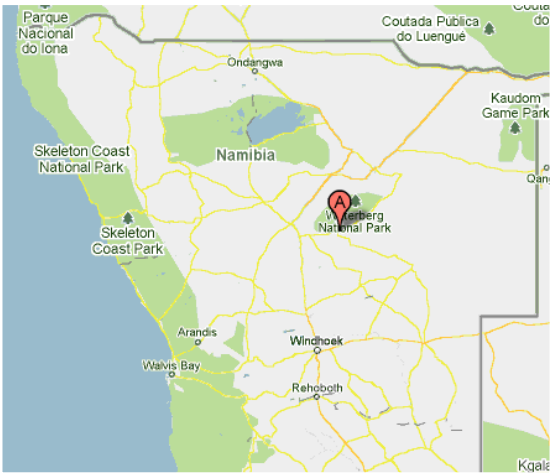
Panel Efficiency:

Though normal business does not reach the limits of Mr. Antindi's system, other innovative practices have drained his battery. If given enough capacity, he would like to run a computer off solar energy to provide typing services for his customers. He has attempted to use his personal laptop on the system and drained the battery in around an hour.

Market Analysis:

As the chief of his village, Mr. Antindi has a unique avenue for advertisement. Though the shop is in his home, people see the system when they come to speak with him. Also, when he first received the system he brought it to a town meeting to let people know what services he would begin to offer. Additionally, since he and his wife both work within a school, they have told the schoolchildren to tell their parents about the system.

One other shop in the area offers cell phone charging using a 12V car battery for the same price as Mr. Antindi. Though this other shop offers competition, he still receives a fairly dedicated base of customers.



Shop Description: The Okakarara shop is in a village of about 200 residents, located 15 km from the closest grid connection. The solar system is located in Ms. Kaangunde's home and operates from 6am-9pm. On average 5 customers visit the shop per day, with as many as 20-25 on the weekends. The shop sells cell phone covers, recharge vouchers, and occasionally meat in addition to cell phone charging and haircutting.

Entrepreneur Description: Ms. Kaangunde and her husband have lived in the Okakarara area for over 40 years. Mr. Kaangunde has a college education but no previous business experience. Ms. Kaangunde offers haircutting services, but is not confident in her abilities so the service is not often utilized by her customers.

Sales Summary:

Service/Month	10/09	11/09	12/09	01/10	02/10	03/10	Total N$
Cell Charging	160	277	195	189	168	197	1186
Haircutting	-	-	-	-	30	-	30
Other charging	-	-	-	-	-	-	0
Add'l services	-	-	-	-	24	-	24
Total N$	160	277	195	189	222	197	1240

Notes: Cell phone charging costs N$3. Haircutting services are N$20 for adults and N$10 for children.

Panel Efficiency:

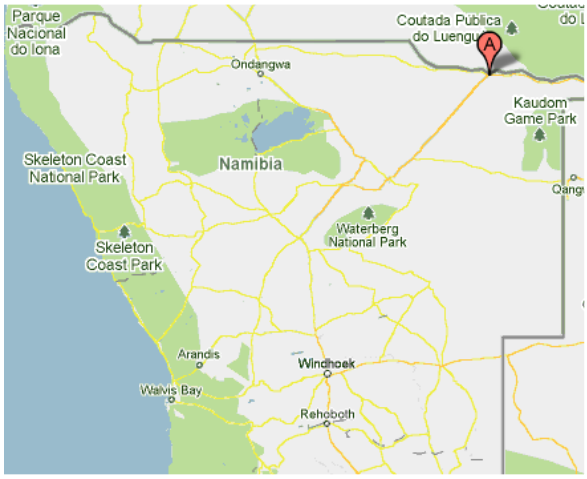
When conditions are favorable, the system provides a more than adequate amount of energy for Ms. Kaangunde and her customers. During cloudy days, Ms. Kaangunde uses her car to charge customers' phones. She damaged her AC inverter by plugging in a fridge, but was still able to charge cell phones.

Market Analysis:

There are other people in Ms. Kaangunde's village who offer cell phone charging for prices as low as N$1; however, people still visit Ms. Kaangunde's shop because of the quality of customer service. Nearly everyone in Claudia's village utilizes her shop for their charging needs. Ms. Kaangunde personally visited all her neighbors to inform them of the opportunity when she received it. Ms. Kaangunde allows her customers to pay on a credit system, but it has been problematic as people have defaulted.

Anomalies:

While people in the village are kind, Ms. Kaangunde reported some jealousy and hostility towards her due to the system. As a result of this hostility, one of the system's batteries was stolen in the past. The other shop owners in the area tell the villagers not to charge from her.



Shop Description: Koro village is located in the northeastern corner of Namibia about 18km from the closest functional grid connection. The grid extends into the village but will not be operational until at least May and only within a 500m area within the village. The shop is open from 10am-12pm on the weekends and 10am-7pm during the week. The shop also functions as a shebeen (small shop/social gathering place) and is popular at nighttime.

Entrepreneur Description: Mr. Chanel has lived in the Koro village/Rundu area for over 5 years. He has a high school education and some basic skills training. He has 2 years of business experience operating a joinery.

Sales Summary:

Service/Month	Oct 09	Nov 09	Dec 09	Jan 10	Feb 10	Mar 10	Total N$
Cell Charging	310	195	315	420	265	-	1505
Haircutting	348	64	169	243	136	-	960
Other Charging	-	80	40	80	40	-	240
Add'l Services	-	-	-	-	-	-	0
Total N$	658	339	524	743	441	0	2705

Notes: Cell phone charging costs N$5, haircuts cost N$10-12, and beard trimming costs N$4.

Panel Efficiency:

Mr. Chanel has not reported that energy demand is higher than the energy supply. He manages to run a shebeen until midnight on the weekends using lights run off of solar energy. His freezer for drinks is run using gas but increased solar system capacity may allow him to cut his gas expenses.

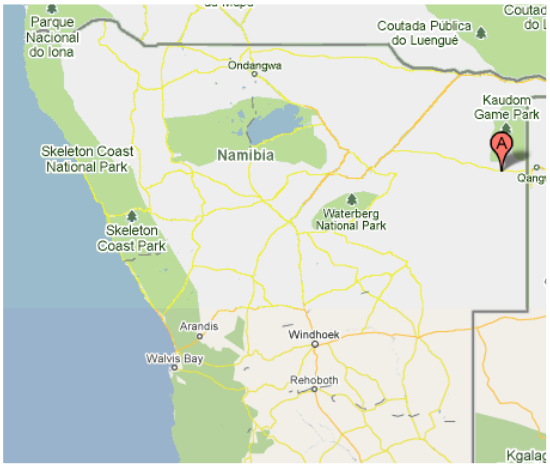
Market Analysis:

Running a shebeen alongside Mr. Chanel's solar business is key to his success. The lights from his system allow his customers to stay later than otherwise possible increasing his shebeen profits. The consequent ease of access to his charging services positively affects his solar profits as well. He has also held braais (barbeques) at his shebeen as a means of advertisement as people would come for the braai and ask about the system.

Anomalies:

Mr. Chanel has had customers utilize his shop to charge portable DVD players. The price of charging was the same amount as cell phone charging, but he did not indicate a difference in his records. He keeps a radio on in the shop and charges it using the system.

Shop Description: The Tsumkwe shop only operated for 2 out of 6 months during December and part of January. The entrepreneur used the system and then had to move to a different location due to an outside occupation. He turned the system into the DRFN because he was unable to support it and could not find reliable help.



Entrepreneur Description: There is no entrepreneur recruitment evaluation available for Mr. Musongo, but he does have knowledge of record keeping and shop operations.

Sales Summary:

Service/Month	Oct 09	Nov 09	Dec 09	Jan 10	Feb 10	Mar 10	Total N$
Cell Charging	-	-	21	3	-	-	24
Haircutting	-	-	423	45	-	-	468
Other Charging	-	-	-	-	-	-	0
Add'l Services	-	-	-	-	-	-	0
Total N$	0	0	444	48	0	0	492

Notes: Cell phone charging costs N$1.5, and haircutting services cost between N$5 and N$20.

Panel Efficiency:

During the months Mr. Musongo maintained his shop he did not experience any lack of capacity with his solar charging system.

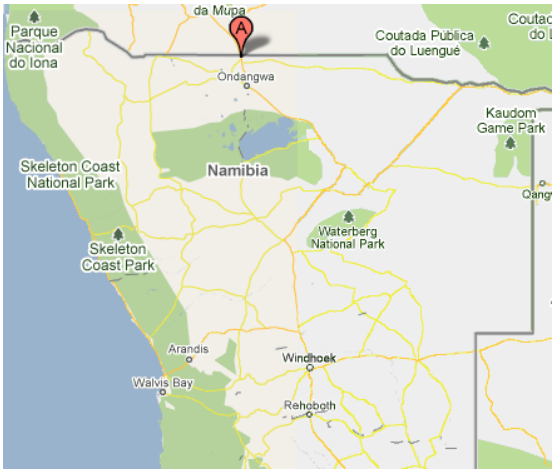
Market Analysis:

Though Tsumkwe is powered by a diesel generator, only a portion of the population has access to that electricity and only at certain times of day. As shown by December's figures, access to haircutting services is greatly needed and produces a great deal of profit. Mr. Musongo's relative already runs his own haircutting business though he does not own a shop. Should Mr. Musongo allow his relative to use the system on a commission or salary basis, both could benefit from the use of solar energy.

Anomalies:

The system will be returned to Mr. Musongo in the near future. He will attempt to run the shop with help from his wife and his brother after teaching them proper record keeping techniques. He will try to visit the shop every one or two weeks in order to check in on and monitor shop operations.

Shop Description: The Engela shop is located close to the Angola border and is about 3 km from the nearest grid connection. Before the implementation of the solar system, the Engela shop provided products such as groceries and cell phone airtime. The system is currently located in the entrepreneur's home for security reasons, but it will soon be moved to his nearby shebeen.



Entrepreneur Description: Mr. Haimbodi has lived in the Engela area for about 3 years. He has a high school education and almost 2 years of business experience.

Sales Summary:
Notes: To date, the entrepreneur has not submitted any financial data to the DRFN.

Panel Efficiency:

Mr. Haimbodi used the system sparingly for business purposes but ran the lights and a radio for his family. Neither personal uses were reported to have drained the battery.

Market Analysis:

The Engela shop has not been operating up to DRFN standards. Mr. Haimbodi chose to put the system in his home instead of in the shebeen he owns nearby for fear it would get stolen or damaged. As a result, the number of people utilizing the system is extremely low.

Other factors have decreased business as well. After receiving the system, Mr. Haimbodi noticed jealousy from his neighbors because he received the system for free. Within two months, others had bought cheaper versions of his solar panels and used the electricity for their own homes and families. Mr. Haimbodi reports these panels are of lesser quality and some have already broken. These families will need energy services again and may become customers.

Due to location of his home and the sparse distribution of the community, there is low traffic past his home. Once the system is moved to his more central shebeen, the energy services will receive more attention.

Conditional Agreement:

The system was to be removed because Mr. Haimbodi did not send his financial records to the DRFN. However, Mr. Haimbodi was given an extension of two months on a trial basis. Within this trial period, he must adhere to three conditions: move the system from his home to the shebeen, advertise the system and its cell phone charging and haircutting services, and send his monthly financial records to the DRFN. If any of these conditions are not met, the DRFN will remove the system at the end of the trial period.

Appendix B – Entrepreneur Interview Questions

Name: Cell Number: Reference #:

Age: Outside Occupation: Location:

Gender:

Q1: What are the hours of operation of your shop?

Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Open							
Close							
Peak hrs							
Customers per day							

Q2: What energy services do you offer …?

Offered	Daily	Non-daily	Since PVS	Do Not	Want to?
Cell phone charging					
Lantern purchasing					
Lantern charging					
Hair cutting					
12V battery charging					

Q3: Why don't you offer certain energy services?

_____

_____

_____

Q4: When/why do you offer non-daily services?

_____

_____

_____

_____

_____

Q5: What other products/services do you sell unrelated to energy products?

_____

_____

_____

_____

_____

Q6: Have you attracted new customers because of the PVS?

Yes No

How many customers did you have before receiving the PVS?		How many customers do you have now that you have the PVS?	
0-10 per week		0-10 per week	
10-25		10-25	
25-50		25-50	
50-100		50-100	

Q7: Have you had to turn away customers because of technical problems? Why?

Yes No

_____

_____

_____

_____

_____

_____

Q8: What PVS system faults have you experienced?

System Faults	How many times	Length of time	Did normal business still occur?	Why did this happen?	What was the resolution?
Run out of power					
Lack of phone chargers					
Cloudy Days					

Q9: In what way do you use the PVS for personal means?

_____

_____

_____

_____

_____

Q10: In what way do you use the two lights that came with the PVS?

_____

_____

_____

_____

_____

Q11: Is your shop separate from your home? Yes No

Q12: Have you advertised your energy service?

Method of Advertising	Used	How often	Cost per use	Increased business? (How much)
Word of mouth (active)				
Fliers				
Sign				
Radio				
Discounts				

Q13: Do you have employees in your shop? Yes No

Names of employees	Association to shop owner	Method of payment

Q14: What method of record keeping do you use?

_____

_____

Q15: What business practices do you use?

Pay Before		Receipts	
Pay After		Appointments	
Credit			
Loans			

Q16: Have there been any issues with these practices?

_____

_____

_____

Q17: How do you think the community views you?

Respectful		Friendly	
Jealous		Helpful	
Excited		Knowledgeable	
Professional			

Q18: Have you made improvements to the PVS since receiving it?

Yes No

_____

_____

_____

Q19: Has there been attempted vandalism, break-in, or theft?

Yes No

_____

_____

_____

_____

Q20: Did you have to do anything extra for the PVS to work?

Yes No

_____

_____

_____

_____

Q21: What other services should the PVS offer that it does not already provide?

_____

_____

_____

_____

Q22: Do you have recommendations for hardware improvements to the PVS?

_____

_____

_____

_____

Q23: If you could, would you buy the system? Yes No

Q24: Can you buy the system? Yes No

Q25: What method would you like to use to pay for the PVS?

Paid in full	
Payment plan	
Loans	

Q26: Have you been saving money since receiving the PVS? Yes No

_____

_____

_____

Q27: How would you rate your performance as a shop and why?

_____

_____

Appendix C – Community Member Survey

Name:	Age: 0-15 18-25 25-35 35-50 50+	Location:
Occupation:	Gender:	Reference #:

Q1: What energy sources do you use at home?

paraffin		Grid energy		dung	
LPG		Solar energy		manual	
wood		diesel		plant	
12V battery		petrol		charcoal	
candles		1.5V battery			

Q2: How close is your home to the nearest electrical grid?

< 1 km	1-5km	5-10 km	10-25 km	25-50 km	> 50 km

Q3: Where do you purchase these products?

_____

_____

Q4: Are you aware of the existence of [solar shops] in your area?

Yes No

Q5: How did you hear about the solar shop?

Word of mouth
Signage
Radio
Pamphlets/fliers
Other _____

Q6: Do you utilize the solar shop?

Yes No _____

Q7: How often do you use and how much do you pay for the following services?

Service	N$	Frequency	Units	Elsewhere
Cell charging			week month	
Hair cutting			week month	
Lantern charging			week month	
Lantern purchase			week month	
12V battery charging			week month	
other			week month	

Q8: Do you think the prices for services are acceptable?

Service	Price	Unacceptable (too high)	Acceptable (fair)	Very acceptable (too low)
Cell charging				
Hair cutting				
Lantern charging				
Lantern purchase				
12V battery charging				
other				

Q9: If the shop offered the following products, would you purchase them there and what else would you like to be able to purchase?

12V batteries		LPG			
wood		paraffin			

Q10: If you own/did own any of the following products, would you charge them at the shop if it was able to?

mp3 players		Camera batteries		
laptops		Batteries		

Q11: What mode of transportation do you use to get to the shop and how long does it take?

MINUTES				COST N$
		Bicycle		
		Walking		
		Taxi		
		Bus		
		Private car		

Q12: How regularly is service available?

Never		Seldom		Occasionally		Often		Always	

_____

_____

Q13: How safe do you feel your belongings (cell phone, lantern, etc) are at the shop?

Very unsafe		Unsafe		Moderately safe		Safe		Very safe	

Q14: How is the quality of customer service?

	Not at all	Kind of	Some-what	Very	Extremely
Friendly					
Helpful					
Knowledgeable					

Q15: Are there other locations where you can obtain energy services?

Yes No

_____

_____

Q16: Do you feel that establishing another solar energy shop in the area would create competition?

Yes No n/a

_____

_____

Q17: Do you like supporting the shop in your area?

Yes No n/a

_____

_____

Q18: Do you know anyone who uses services from the energy shops for their own business?

Yes No

_____

_____

Appendix D – Area Evaluation

Picture Checklist

	Whole shop
	Solar panel
	PV unit
	Team with entrepreneur
	Surrounding area
	Shop products
	Employees
	Customers

Layout type:

Scattered Clustered Even

Organized Irregular

Density of structures:

Spacious Comfortable Close-together Crowded

General size of settlement:

Small Medium Large Extensive

Estimated Distance to Grid Electricity

0-5km 5-15km 15-30km 30-45km 45-60km +60km

Terrain

Hilly		Flat	
Fertile		Barren	
Water nearby		Dry	
Rocky			

Comments

_____
_____
_____

Quality of structures

Status of disrepair

_____
_____
_____

Materials for structure

_____
_____
_____

Shop Description

Relative location of shop in community

_____
_____
_____

Shop Structure Quality

_____
_____
_____

Additional Comments

_____
_____
_____

Appendix E – Area Evaluation Summary

Havanna 1	Havanna is a rapidly growing, densely populated, informal settlement outside the city of Windhoek. There are a large number of dwellings crowded together and spread over an extensive hilly area in what seems an irregular manner. Most buildings are made out of corrugated metal with wood supports and other miscellaneous materials. While the settlement is located within a grid area, none of the dwellings have access to this electricity. Venasius's shop is well marked and located off of a main road with regular car and pedestrian traffic. The shop is mainly corrugated metal with a concrete floor and a wall serving as a door that opens during shop hours of operation. There is seating inside the shop and lights on both the inside and outside. The shop sells various other products and keeps them in a separate shop area behind a metal grate. The solar panel is placed on the roof and the solar system is mostly kept inside behind the grate.
	
Havanna 2	Havanna is a rapidly growing, densely populated, informal settlement outside the city of Windhoek. There are a large number of dwellings crowded together and spread over an extensive hilly area in what seems an irregular manner. Most buildings are made out of corrugated metal with wood supports and other miscellaneous materials. While the settlement is located within a grid area, none of the dwellings have access to this electricity. Justina's shop is central within the settlement, near a tar road, and off of a smaller road with moderate foot traffic. The shop is run out of Justina's home which is small. It has a dirt floor and benches for seating. Her home consists of two structures and is surrounded by a fence. She cares for five children at home. The solar panel is placed outside and shifted during the day and the solar system is inside the home.
	
Ombuojo	The village of Ombuojo is about 11 km from the main town of Okakarara and a grid connection. The village is set up in a well-spaced ring of dwellings around a moderately sized central animal and crops pen. The surrounding area is covered in underbrush where most of the animals roam freely. The houses are mainly made of cement or large bricks with corrugated metal roofs and glass windows. Claudia's shop is located within the community circle near the road entering the village. She runs the business out of her home. Her home is well sized and made of cement with a corrugated metal roof and glass

	windows with bars. The solar panel is mounted permanently on the roof and the solar system is inside her home.
	
Gam	Gam is a very remote town over 400 km from any grid connection and 100 km from the nearest town. The town is rather irregular in both layout and structure quality and type. The town is not over crowded and there seems to be a town center in which the stores and shebeens are located. Buildings are made from various materials such as tires, corrugated metal, thatch, sticks, cement, tarps, wood, rocks, clay, and a few tents. Alex's shop is located in this central portion and is made out of rock and cement with a corrugated metal roof, rock and cement floor, glass windows and wood doors which can be locked. Inside the shop there is a separate area for shop products behind a wood and metal grate counter. The solar panel is mounted permanently on top of the roof and the solar system is inside behind the counter.
	
Koro Village	Koro village is over 10 km away from the large town of Rundu, but parts of the village, including Malyatta's shop, have recently been given access to grid electricity due to the government installing electricity in the school and within a 500m area around the school. The village is arranged in house clusters surrounded by farm crops. There are foot paths between these clusters and a main dirt, gravel road running through the village. The huts are mainly comprised of earth materials including trees, sticks, thatch, clay, and rocks. The shop is located in one of these house clusters, but not necessarily in a central location. The shop is moderately sized and made with rocks, clay, and sticks for walls, a corrugated metal roof, and doors with padlocks. There is a tarp to create an overhang and a sign on the outside advertising the shop products and services. Inside the shop, there is a separate area for products behind a wood counter. The solar panel and solar system are kept at Malyatta's home when the shop is not open. During our visit the shop was closed and many members of the community were at church.

<table>
<tr><td colspan="2">    </td></tr>
<tr><td>Enyana</td><td>The village of Enyana is located around 15-30 km away from any grid connection. The area of the village is rather large whereas the amount of people living within the village is small. There are irregular clusters of dwellings surrounded by farmland and crops. There were two types of dwellings one made of sticks, rocks, and thatch and another with corrugated metal and wood. David’s shop is located in the village “center”. It is large and made of corrugated metal with a concrete floor. One wall serves as a door, which locks, and stays open during shop operation. The shop products and the solar system are located behind a counter made of wood and particle board separated from the shop space which holds a pool table and seating. The solar panel is placed outside the shop on the ground during shop operation.</td></tr>
<tr><td colspan="2">    </td></tr>
<tr><td>Omboto</td><td>The village of Omboto is located 15km from the nearest grid connection. Most members of the community are farmers and live in clusters of homes surrounded by open fields and crops. Paulus has two locations where he does business. Due to fears of vandalism and theft, he keeps the solar system and solar panel at his home where he has permanently affixed the solar panel on the roof. His shop in the village “center” sells other various products. His home is made of brick with a concrete floor, corrugated metal roof and locking wood door. His shop is made of corrugated metal with a concrete floor and counter, behind which the products are located. The shop is moderately sized and has a portion of a wall that serves as a locking door. The village dwellings are made from various materials including concrete, corrugated metal, sticks, thatch, and clay.</td></tr>
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<tr><td>Karetes</td><td>The village of Karetes is located within a small valley about 10 km away from the nearest grid connection in Khorixas. The dwellings are scattered throughout the village with large spaces in between individual homes. These homes are made of cement, rock, clay, corrugated metal, and wood, and they are usually within a plot surrounded by a fence. It cannot be seen where Magdalena’s shop is located in relation to the other dwellings in the village. The closest homes are about a five minute walk from her shop. Her shop is run out of a small room separate from her home which is made of clay with a corrugated metal roof and a cement floor. She has a stand for the solar panel outside this room and keeps the solar system within the room during shop operation.</td></tr>
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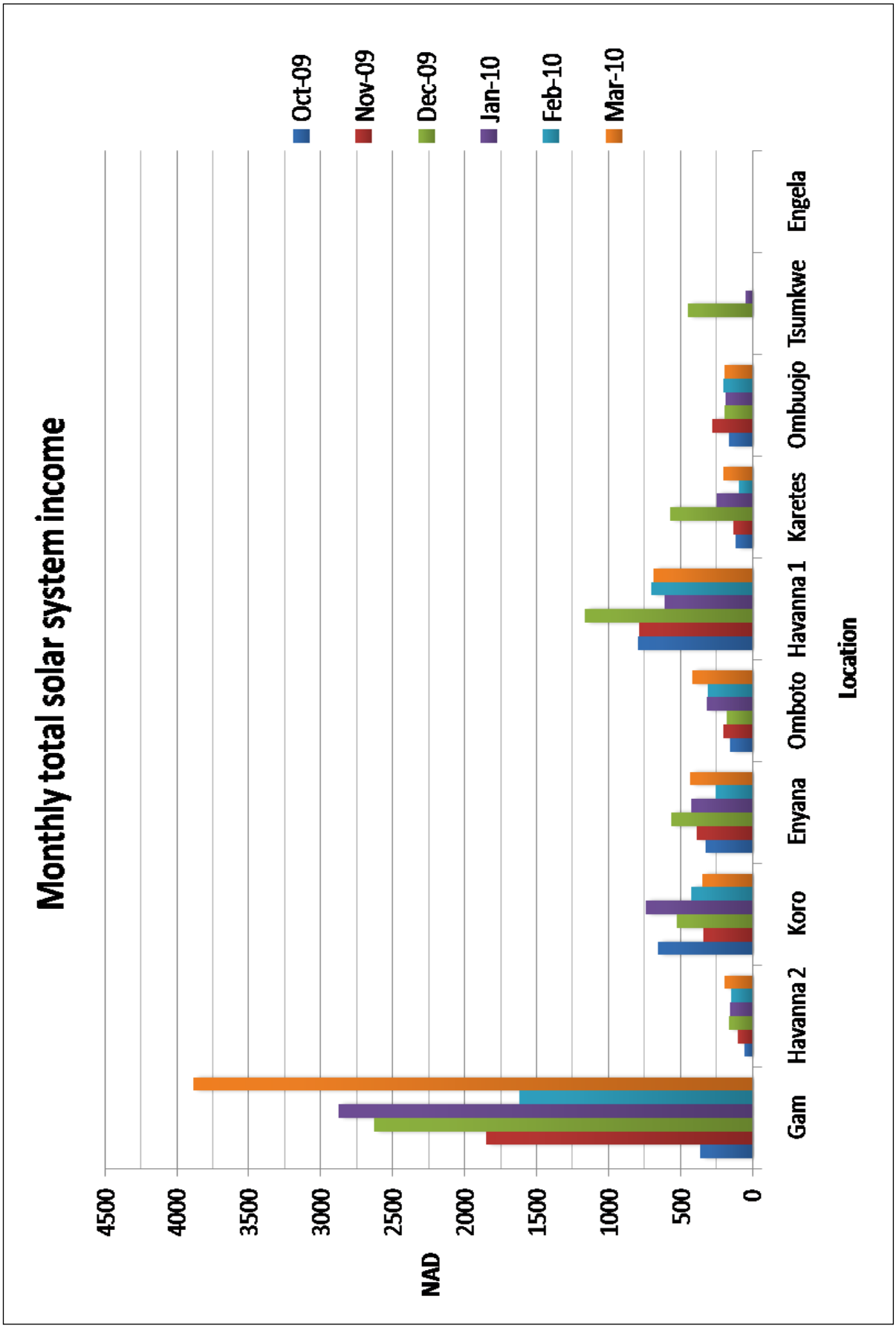
Appendix F – Financial Records, Totals by Month



Appendix G – Financial Records, Totals by Service