Off-Grid Electricity Access and its Impact on Micro-Enterprises: Evidence from Rural Uganda

by
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"History will be kind to me, for I intend to write it!"
Sir Winston Chuchill (1874-1965)

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Foremost I'm thankful to God for the path set in my life, granting me the serenity to accept the things I cannot change; courage to change the things I can; and wisdom to know the difference. There were many times that I questioned if I could make it to this point, but every time I remembered that they that wait upon Him, He shall renew their strength.

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I made it this far only because I stand on the shoulders of great giants. Shukran Jazeelan!

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ABSTRACT

The history of development shows convincingly that no country has substantially reduced poverty without massively increasing the use of electricity. The development of micro-enterprises in rural areas of Uganda is linked with increased access and use of electricity services.

In this study, I combine quantitative and qualitative methods, including informal surveys, intra-business energy allocation studies and historical analysis, to analyze off-grid electricity access among micro-enterprises in rural western Uganda. I explore the linkages between off-grid electricity access and the influence it has on micro-enterprises. Data is obtained from 56 micro-enterprises located in 11 village-towns within 3 districts in Uganda. In studying the micro-enterprises, the focus is on the services that are provided by electricity from modern energy carriers. The type of equipment used, forms of transportation, technical support, level of understanding and education of the entrepreneur, financing for energy equipment, and the role of donors are discussed in this thesis. Qualitative methods are used to allow for new insights and prioritization of concepts to emerge from the field rather than from theory.

Micro-enterprises in rural Uganda create income for the poor; they are resources for poverty reduction. With price adjustments, it becomes possible for those who live below the poverty line, nominally less than $1 a day, to afford the products and services and therefore mitigating the vicious cycle of poverty. Energy consumption

among the micro-enterprises is at an average of 0.13kWh/day. The cost of accessing this amount of electricity attributes to about 50% of total revenue. I find that the "practices" used in off-grid electricity access lead to situations where the entrepreneurs have to evaluate pricing and output of products and services to generate higher profits. Such numbers indicate the need for appropriate technologies and profitable policies to be implemented.

The data indicates that without subsidies, credit-based sales and better financing options, it is unlikely that access to electricity will increase beyond the levels established in the existing cash market. Concerns about equity and other social issues indicate a need for careful attention to the implications of policy choices and the processes that influence the use of technology.

CHAPTER I

Introduction

1.1 Modern Energy Services as a Basis for Development

It is well known today that technological, industrial and economic progress is heavily dependent on the readily available energy; the enormous technological, industrial and economic advancement of the so-called developed countries was primarily made through exploitation of Earths vast reservoir of inexpensive fossil fuels. These fossil fuels, often imported from countries that lack the science and technology required for their effective utilization, helped the developed countries to attain affluence. They also help to control the destinies of less developed countries of the world. Today, developed nations, with one fifth of world's population consume four-fifths of world's fossil fuels.

In many of the poorest countries, a large fraction of the population is unable to access modern energy services such as grid-electricity, solar photovoltaics, fuel-based generation and the like. A substantial fraction of the population relies on biomass or dung for cooking fuel and heat; on kerosene wick lamps, battery-operated flash lights, or candles for lighting; and on human or animal energy-based mechanical power for tilling and weeding land, grinding and crushing, agro-processing, or transport. The poorest of households spend a large portion of their total income and human

resources on energy because some forms of energy are absolutely essential to meeting such basic needs as cooked food and transportation. Those who do have access often pay dearly for less modern energy services of much lower quality - meaning that the services are erratic and unreliable. Insufficient and unreliable electricity limits the ability of enterprises to expand their activities, to be competitive or to create new activities or jobs. The largest concentrations of the energy poor are currently in sub-Saharan Africa and South Asia as shown in figure 1.1, projecting to the year 2030.

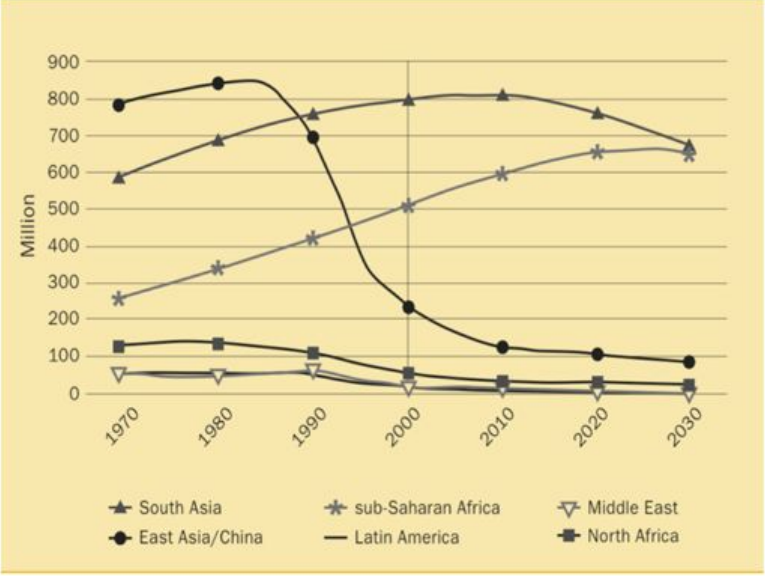

Figure 1.1: Number of people (actual and projected) without electricity, 1970-2030, by region [UN 2005]

Even urban areas where there is access to grid electricity, supply is often unreliable, hence services which are best derived from electricity may remain inaccessible. In addition to generation or supply shortfall, and insufficient distribution infrastructure, the lack of access to electricity further hampers the use of electricity services, affecting economic development.

1.2 Defining the Research Question

Micro-enterprises are important in their role as contributors to the economy. In this research, the objective is to understand off-grid electricity access and its impacts on micro-enterprises in rural areas. Aggravating this process is the fact that the topic of electricity is nearly always assessed from a supply perspective, which perceives electricity as a product rather than a service [Ramani and Heijndermans, 2003]. Therefore attention both from policy and project practice hardly reaches beyond supply. Understanding the linkages between increased access to off-grid electricity proves important in the development of the micro-enterprise.

The research question seeks to identify off-grid electricity access strategies in facilitating and supporting the micro-enterprise in rural areas of Uganda that are not connected to the grid. In order to provide the answers to the general question, the research addresses the following specific research questions:

- What are the methods of electricity access by the micro-enterprises?
  - *What are the methods in electricity generation? (petrol generators, diesel generators, solar photovoltaics, etc.)*
  - *What equipment/devices are used for generation and storage of electricity? (Discussion of devices such as generators, inverters, batteries)*
- What is the distribution of the micro-enterprises and their dependence on electricity services?
  - *Distribution based on use such as lighting, refrigeration, customer services, forms of access etc*

- What is the role of energy-economics in the micro-enterprise?
  - *Access to capital for investment - financing options, micro-financing, donors, sellers of equipment, credit-based sales, etc*
  - *Cost of electricity access*
  - *Affordability for electricity and the capacity-to-pay*
- What are the constraints to electricity access? Distance and transportation, weather, education, theft, tribalism, and other unknown factors
- What influence on social and economic empowerment does access to electricity have? Influence on assets, characteristics on the micro-enterprise and livelihoods of the entrepreneurs.

The complexities of answering these questions provides a basis for detailing the mechanisms that stimulate the understanding of the linkages between access to electricity and micro-enterprise development, allowing policy makers and stakeholders to take actions, increasing awareness for the entrepreneurs on the impact of electricity on income generating activities and finally reducing poverty.

1.3 Research Approach

Since this research is set up to gain deeper insights into the practices of the micro-enterprises in accessing off-grid electricity, empirical data collection and analysis form the core of the study. Qualitative methods are used to allow new insight and prioritization of concepts to emerge from the field work rather than from theory. While the analysis focuses on the process of electricity access, its impacts on the micro-enterprise are also as important. Comparisons of micro-enterprises (within and between the village towns) are used to analyze markets, energy access and supply, and institutional context. Research locations are selected based on accessibility of towns and knowledge of the areas by interpreters.

Literature based on electricity supply practice in combination with pilot studies done in the Himalayas [Kooijman-van, 2008] guide the selection and review of theory, which is used to deepen insights, provide and refine concepts and propositions to be tested in the field and to structure both data collection and analysis; thereby forming a cyclic deductive and inductive approach of fieldwork and theoretical reflection. The approach is a combination of the methodologies suggested by [Yin, 2003] and [Eisenhardt, 1989]. Yin's approach of selecting case studies, based on propositions from literature and comparing cases to build internal validity of findings is combined with Eisenhardt's suggestion to base the selection of theory and literature on findings that emerge from field research. Such an approach allows a well prepared and guided selection of case studies while at the same time keeping an open attitude to findings from the field. Comparisons of micro-enterprises are an extension of Yin's search for rival explanations, and are used to analyze markets, electricity access and institutional context.

The perspective of the entrepreneur is used not only to gain deeper insights into motivation for electricity access and benefits but also on the motivation or perceived barriers against the access, key lessons learned from the field. The empirical data collection is based on qualitative and quantitative research techniques. Further semi-structured interviews and open discussion with key informants, as well as observations, serve to improve internal validity of data through triangulation of data. The triangulation method is used, as shown in figure 1.2 for data validation and is explained in detail in Chapter II.

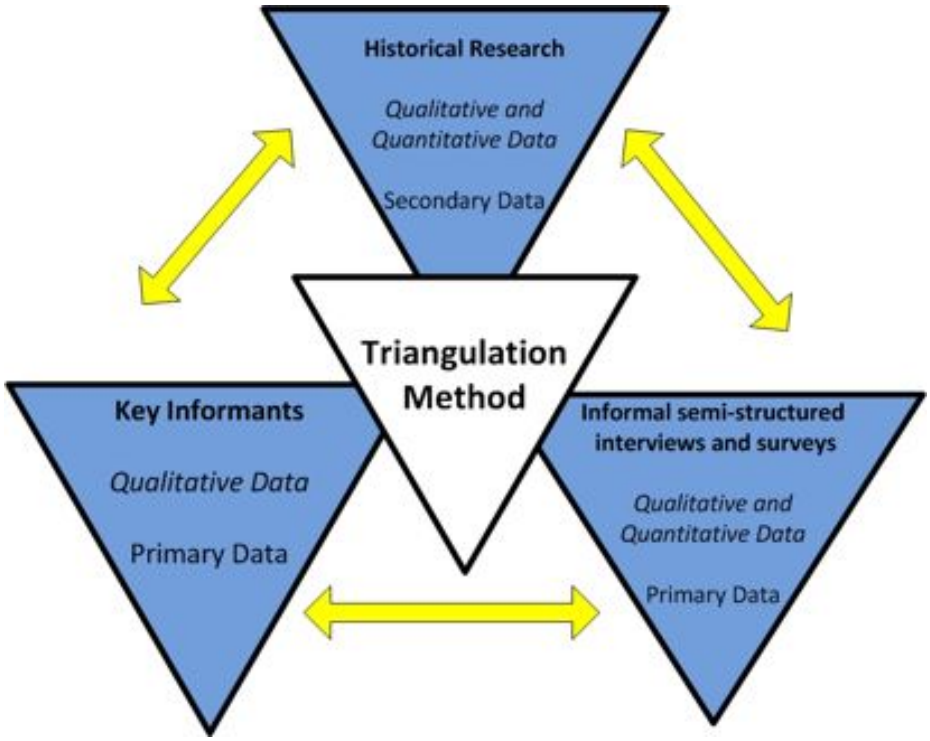

Figure 1.2: Data Triangulation Method

1.4 Evidence from Rural Uganda

Uganda, referred to as the Pearl of Africa, is endowed with significant natural resources, including ample fertile land, regular rainfall, and mineral deposits. However, the electricity demands have historically been higher than supply, despite the considerable unexploited renewable energy sources for energy provision and provision of energy services.

The fieldwork data is obtained from fifty six off-grid micro-enterprises, located in eleven village-towns within three districts (Kabarole, Kamwenge and Kyenjonjo) of western Uganda, as indicated in Figure 1.4. Other micro-enterprises are studied but not included in the data due to several factors such as they do not offer any services dependent on electricity, or are in the Fort Portal area where grid electricity is available intermittently. The selection of trips for the fieldwork varies with the different seasons as so have a better understanding on how weather affects access to electricity. The fieldwork was conducted during the following periods: May 2008, October-November 2008, April-June 2009, and October-December 2009.

Figure 1.3 shows a map of Uganda, with the areas covered highlighted. Statistics as given by the United Nations indicate that Uganda is classified as a mid-HDI country(Human Develop Index - described in the definitions page).

Figure 1.3: Map of Uganda [UN 2003]
Area: 241, 000 KM^2, Population: 30 Million, Population Growth Rate: 3.4% p.a.
GDP Per Capita: US $1454, GDP Growth Rate: 6% p.a.. HDI Value: 0.505
Population Without Grid Electricity: 24.6 Million

The geographical distribution of micro-enterprises proves to be challenging due to the poor infrastructure (roads) and the frequent rains which makes it impossible to travel thus being immobile for 2-3 days before being able to move to the next village town. The following map shows the different micro-enterprises in each of the different towns which include Bigodi, Bishese, Ibanda, Kabujogera, Kahunge, Kichwamba, Kihura, Kyakatara, Kyenjonjo, Kyegegwa, Rwehamba. The categories of micro-enterprises include the following: Bar, Barber, Battery Charging Station, Cell Phone Charging Station, General Store, Hair Salon, Hotel/Resort, Pharmacy, Restaurant, Tailor and Video Hall. The roads are unpaved, or only paved with gravel known as **"murram"** in East Africa, with some rocks bigger than a human's fist.

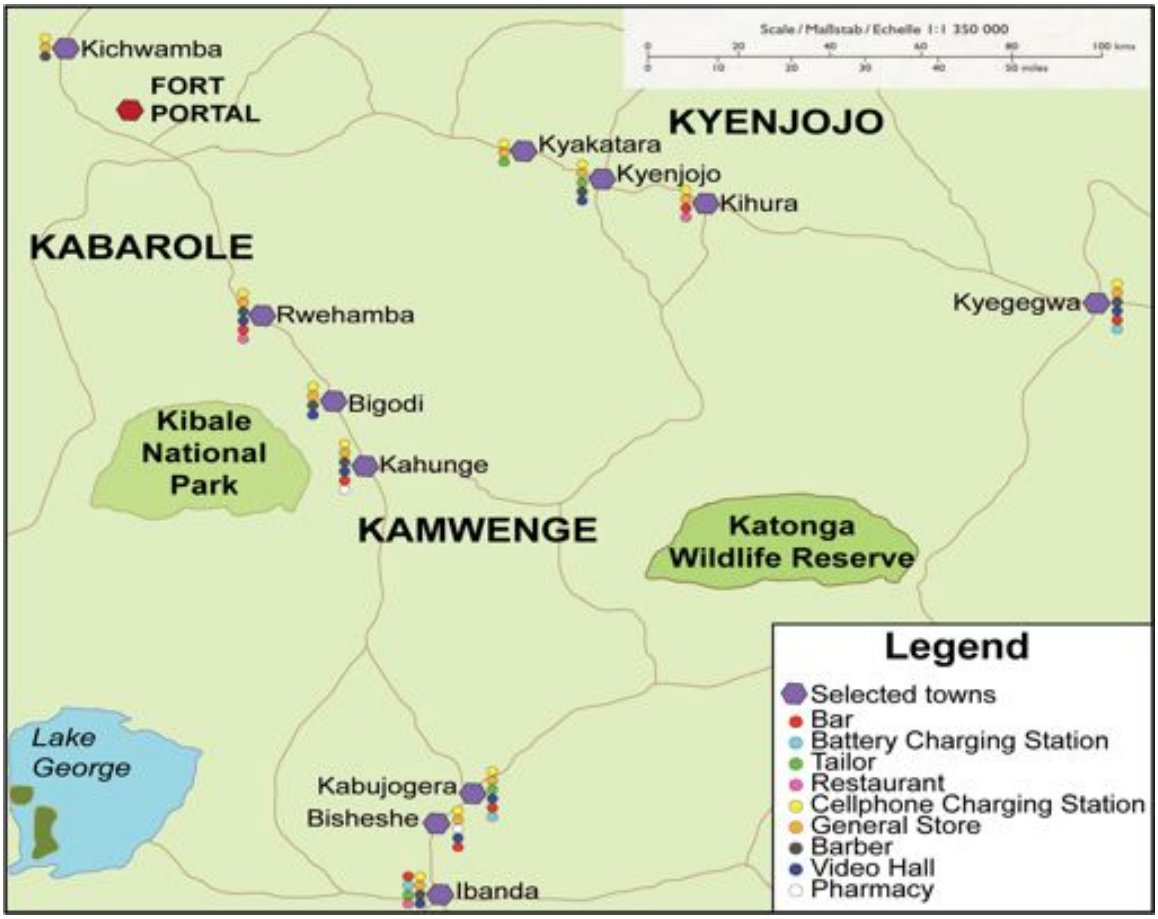

Figure 1.4: Distribution of Businesses in Rural Western Uganda with key showing each of the businesses in each town.

To understand the complexity of electricity access, it is important to understand the current generation capacity. For a long time, Uganda's hydropower generation from the Owen Falls Dam was the sole source of grid electricity. Whereas the installed capacity of the complex is 380 MW (180 MW at Nalubaale and 200 MW at Kiira power plants), the effective capacity of the complex has been as low as 100 MW in 2004/2005, and is up to around 140 MW today. This decline is due to the reduced level of Lake Victoria as a result of a drought in the region since 2003. As a consequence, Uganda has suffered chronic power shortages since 2005.

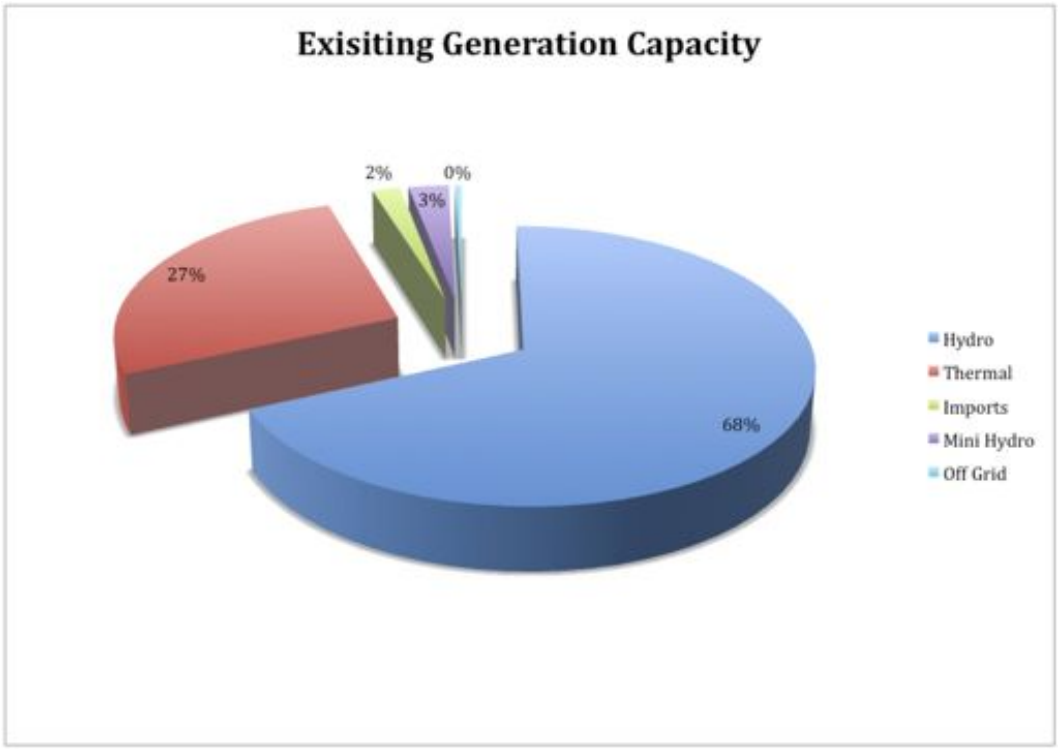

Figure 1.5: Distribution of Existing Generation Capacity [ERA Doc]. Most of the power generated is not distributed through the grid but rather on small scale generation like the micro-enterprises in this research

Progress toward providing greater access to electricity has been slow due to a combination of interrelated circumstance. To understand this from interviews with different stakeholders, a chain of related steps would have to occur in order to have sustainable impacts from the access to off-grid electricity, as shown in figure 1.6.

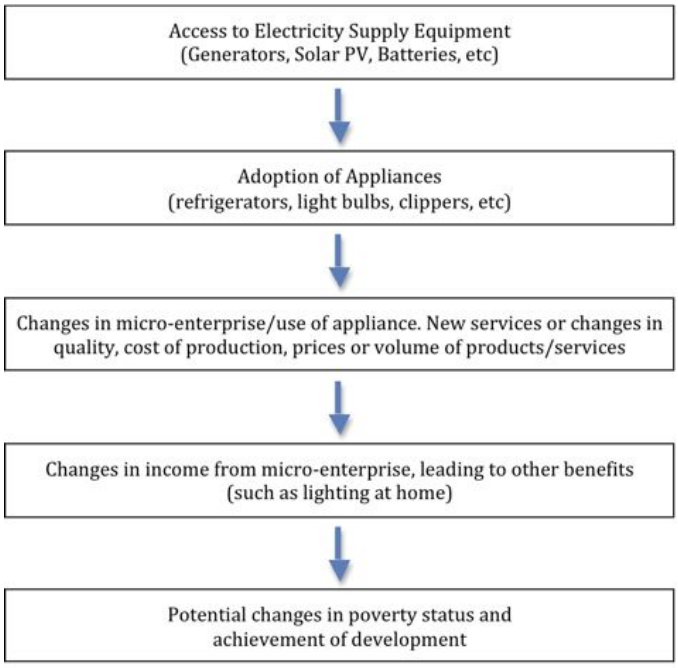

Figure 1.6: The Steps from Electricity Supply Infrastructure to Change in Poverty Status

This chain shows that insights into actual use provide a different picture from the daily expansion of working hours, which is commonly assumed. Despite the fact that the fifty six micro-enterprises have lighting as one of the main uses of electricity, thirty five of them only occasionally remained open in the evening, with only fifteen regularly doing so.

The following quotations are from some of the entrepreneurs indicating the need of such steps to happen.

> *"I have owned this shop for 15 years and recently bought a battery and bulb to provide lighting rather than using a kerosene lamp. I have seen so many changes including more people attracted to my business in the evenings. I even decided to open later at night and have seen customers who would otherwise have not gone out that late to buy an item. Unfortunately, even though I have electricity, I don't have the capital to buy a small refrigerator to cool the sodas and keep milk longer."*

> *"When my cell phone battery dies, I usually walk about 7 kilometers one-way to the nearest charging station. I usually pay UGX 500 (USD 0.25) to charge it but sometimes it may cost me up to UGX 1500 (USD 0.75), depending on the weather, number of customers, or how fast I want my cell phone charged . This puts me out of communication for a while and I never know if there is someone interested in buying my bananas. I use my cell phone for communication with buyers who are interested in my produce."*

A central question for policy makers and analysts is whether these micro-enterprises hold the potential for income growth for their owners, or whether they merely represent a source of subsistence income for low-productivity individuals unable to find alternative work. The ability to assess the extent to which a lack of capital to access electricity is a constraint on business profitability is complicated, finding that most of the entrepreneurs depend on a 'cash market.' Access to capital has shown to be a limiting factor to development thus most micro-enterprises may go beyond the first step in the chain but cannot go past the second due to a lack of financing to acquire electricity generating equipment.

1.5 Guide to the structure of thesis

The objective of this research is to provide the reader with insights into the practices of micro-enterprise entrepreneurs in accessing electricity and how this impacts the dynamics of the micro-enterprise. This overview shows how the structure of the thesis follows from the research questions, and thereby also provides a guide for focused or selective reading into specific subtopics.

Chapter II provides a critical review of literature on the topics that form the heart of this research: energy and poverty reduction, electricity as an innovation for micro-enterprises, micro-enterprises and poverty reduction. This review is used to gain understanding of existing knowledge, and to identify needs for research. The concepts and terms used are also introduced here and the definitions discussed. Also discussed in this chapter is the planning process for rural electrification in off-grid locations through the Rural Electrification Agency (REA) and the Uganda Electricity Board (UEB) which are the two government agencies responsible for the achievements. The aim is to identify patterns of demand and priority areas of need. By creating a demand-side scenario, grid electricity can then be supplied to targeted areas. This chapter covers the current generation capacity, the supply network, the served and unserved, and the future goals of electrification in Uganda.

Sustainable development is literally driven by the electricity sector. In Uganda, the electricity sector has experienced dramatic market liberalization changes in recent years. Chapter III introduces the context in which micro-enterprises operate and the methods used in accessing electricity. This chapter introduces the reader to the data collected forming a reference and basis for the analysis in the next chapters. The impacts of electricity services and growth (profits) and decline (losses) dynamics

of the micro-enterprises based on electricity access are also discussed here. Key energy-economics, socioeconomic and the policy and institutional setting in Uganda. While much of this description is found in the literature, findings from the fieldwork indicated that the typical principles of economics in relation to off-grid electricity do not necessarily apply in the rural settings.

Chapter IV covers the constraints experienced by the entrepreneurs in accessing electricity and how this impacts the growth and development of the micro-enterprise. Several constraints show that off-grid situations face many availability (or the lack there of) and reliability issues that can impede the development and growth progress of the micro-enterprise.

The practices on off-grid electricity access play an important role on the micro-enterprise. These practices determine either growth or stagnancy in the micro-enterprise. In Chapter V, I discuss those practices, the impacts they have and the influence on the assets and characteristics of the micro-enterprise. This chapter focuses on feasible solutions and the recommendations that could be used in off-grid electricity access.

This thesis concludes with Chapter VI which presents a summary discussion on the results of the fieldwork, highlighting aspects of this research and the insights that these have led to. By answering the research questions, links are made to recommendations for interventions to improve the access to electricity and the impacts it has on poverty reduction. The recommendations are positioned in a wider scope such that they can be applied to any developing country.

CHAPTER II

Background and Literature Review

2.1 Introduction

This research looks at the experiences by the entrepreneurs and not so much from other researchers and consultants in the field of rural energy. The reason for this approach is because most research is based on assumptions and advocacy that modern electricity equipment and appliances is good for poverty reduction, but it's more important to understand the processes from energy to poverty reduction and if they actually succeed. Understanding the social and economic aspects of the entrepreneurs serves a crucial component for the success of the study.

This chapter presents a review of a selection of existing literature on the topics of energy and micro-enterprises. The literature reviewed provides a background on the basis of being illustrative for streams of thought, status of knowledge, types of research and relevance to my research as it emerged through the cyclic process of fieldwork and analysis. Impacts of access to off-grid electricity and increase in income generation are closely related to the functioning of the micro-enterprise. Selected indicators and concepts will be used to structure and deepen the empirical data collection and analysis.

Uganda is well endowed with both renewable and non-renewable resources including good climate. Although GDP has increased positively in the last two decades, the positive benefit of GDP growth have not been felt by every household in Uganda.

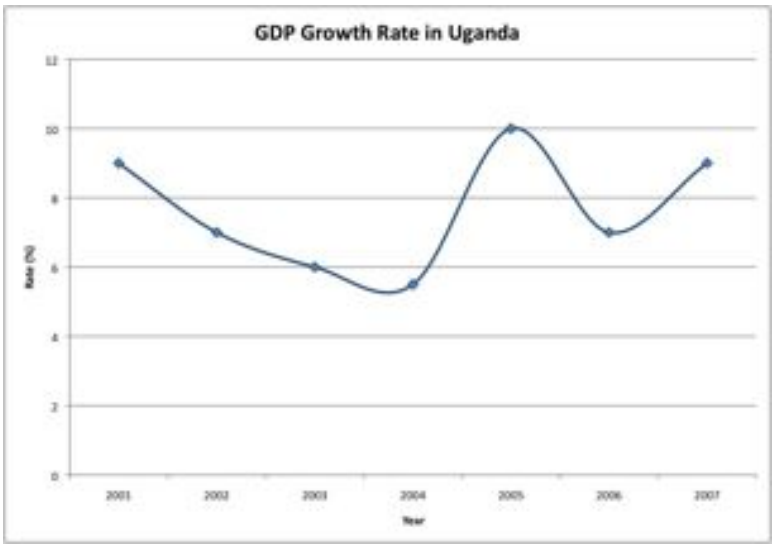

Figure 2.1: GDP Growth Rate in Uganda [UBS, 2008]

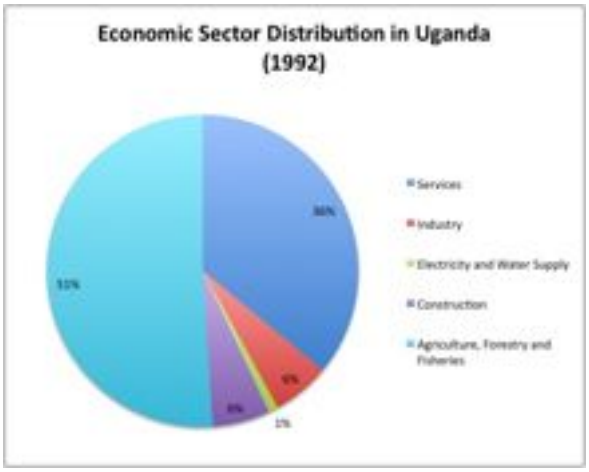

Figure 2.2: Economic Sector Distribution in Uganda for the year 1992 with agriculture having the highest portion compared to other sectors [UBS, 2008]

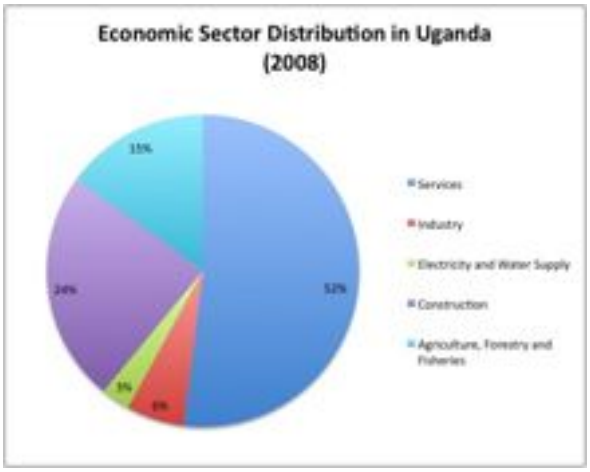

Figure 2.3: Economic Sector Distribution in Uganda for the year 2008, showing very small increase in the electricity and water supply sectors [UBS, 2008]

Poverty and inequality continue to prevail albeit at a reducing level. Lack of electricity access is one of the leading causes of the persistent poverty and inequality. Looking at the economic sector growth, figure 2.2 and 2.3, it is clear that there is a large increase in services and construction which both rely on electricity, but yet the growth in electricity and water supply is minimal.

2.2 Role of Energy in Poverty Alleviation

Energy is an important input to achieving sustainable development, especially in alleviating poverty. In the 1990s, policy makers and international organizations let rural electrification and rural energy supply in general fail due to the problems of converting energy supply into profit making activities in times of economic reforms [IDS, 2003]. This area has become a topic of discussion primarily with respect to poverty reduction [Barnes, 2007]. The recognition of the contribution of energy to implementing the Millennium Development Goals for sustainable development (MDGs) and for poverty reduction strategies is widespread as indicated by several United Nations organizations [WSSD, 2002; DFID, 2002; UN, 2002; UNEP, 2005; IDA, 2005]. The energy challenge to meet the first MDG, "Eradication of Extreme Poverty and Hunger", has two components: income generation and household cooking needs. In this research, the focus is on the first component formulated as follows: *"Energy inputs such as electricity and fuels are essential to income generation, transportation, commerce, and micro-enterprises outputs"* [1]

This recognition has led to an awareness of 'productive uses' of energy on the agendas of many development agencies, including bilateral donors and the Global Environment Facility and its implementing and executing agencies UNDP, UNEP, World Bank, FAO, UNIDO, and regional development banks [White 2002]. More recently, the partnership Global Network on Energy for Sustainable Development GNESD, which was established to strengthen the links between Millennium Development Goals and energy, stresses the importance of energy to generate income so that the poverty cycle can be broken [GNESD 2007]. [2]

[1] MDG text links with energy: United Nations Department of Economic and Social Affairs, "The Energy Challenge for Achieving the Millennium Development Goals" (United Nations 2005) - available at http://esa.un.org/un-energy

[2] GNESD is a UNEP facilitated knowledge network of developing world Centers of Excellence. The main objective of GNESD is to carry out policy analysis on thematic energy issues which can facilitate in reaching the MDGs.

Now that poverty reduction through income generation (through impacts of access to modern energy services) is recognized as a topic by policy makers, the policy requirements for understanding of the mechanisms behind this process have become even more urgent, especially in meeting the MDGs. Additional knowledge on income generation specifically is of interest to energy policy in a development context: economic development, the efficiency and economic viability of supplying energy, especially to rural areas, and the effectiveness of pro-poor interventions. This research has the objective to provide the necessary insights from these different motivations.

Rural energy projects have generally not had the impacts on economic growth and income generation that they were anticipated to provide [World Bank OED 1995; Matly 2003]. This is true for large projects based on grid extension [Schramm 1993; Meadows 2003; Aitken et al. 2008]. Policy makers and project implementers either seem to ignore the impacts of the projects on income generation, operating under assumptions that in order to achieve desired outcomes (for example, greater income-generating opportunities) it is sufficient to produce outputs [Winrock International et al. 2003]. More recently, it has been recognized that a change of focus is required to meet specific demands set by productive uses [Etcheverry 2003; Barnes 2007]. However, understanding which specific inputs or conditions are required is still lacking, as is illustrated later in this review.

The efficiency and economic viability of modern energy supply infrastructure can be increased through local uses of energy for income generation, or the adaptation of energy appliances. In rural areas where low population densities and low energy demand from micro-enteprises, result in high costs of establishment and operation of energy supply infrastructure, an increase in energy demand following from the use of energy for income generation can benefit the economic viability of energy

projects [Barnes 2007; Kapadia 2004], or, as formulated more strongly by [Lamech and O'Sullivan 2002]: "Investment in rural electrification is economically justified only when the emerging uses of electricity are strong enough to ensure sufficient growth in demand to produce a reasonable economic rate of return on investment."

A purely economic approach to improving economic viability of rural electrification is introducing a distinction between areas with economic growth potential for electrification through centralized grid, and areas that will (initially) be provided with lower cost decentralized alternatives, would reduce waste of infrastructure investments [Schramm 1993; World Bank OED 1995]. Currently only 10-50% of the costs of rural electrification are generally recovered, leading to high levels of subsidization [Lamech and O'Sullivan 2002]. A further aspect of improving feasibility of energy projects by productive uses is through the ability to pay for energy services: if energy use does lead to an increase in income generation, the consumers ability to pay for energy services is improved, thereby breaking the vicious cycle of energy poverty and financial poverty [Barnett 2000; Kapadia 2004; IDS 2003].

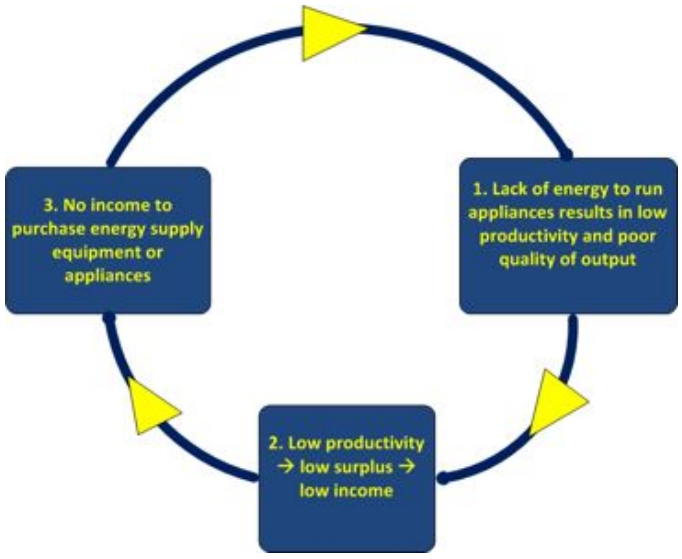

Figure 2.4: The vicious cycle of energy and poverty

2.3 Electricity and the Human Development Index

Macro-level research on the role of energy in poverty reduction has been performed by economists, both from academic and consultancy backgrounds. Micro-level research on this topic has been performed mainly by energy consultants. The literature review, especially for the micro perspective, will therefore be mainly based on the so-called grey literature, which consists of non-peer reviewed reports and publications. As many authors in this field write from an advocacy perspective supporting the role of energy, a positive presentation of findings can be expected.

The bulk of research on energy impacts on poverty takes a macro economic perspective. At a macro-economic level, indeed, there is a correlation between commercial energy consumption and economic growth (GDP), and also between commercial energy consumption and the Human Development Index (HDI). Illustrations of such correlations often appear in discussions on the energy contribution to development and poverty reduction.

The Human Development Index (HDI) is a summary measure of human development that is published by the United Nations Development Programme (UNDP). The HDI provides an alternative to the common practice of evaluating a country's progress in development based on per capita Gross Domestic Product (GDP) . The HDI is the trademark of the Human Development Report (HDR), an independent report commissioned by the UNDP that is written by a team of scholars, development practitioners and members of the Human Development Report Office of UNDP. The HDI has had a significant impact on drawing the attention of governments, corporations and international organizations to aspects of development that focus on the expansion of choices and freedoms, not only income.

The HDI measures the average achievements in a country in three basic dimensions of human development: [3]

- A long and healthy life, as measured by life expectancy at birth (longevity)
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrollment ratio (with one-third weight)
- A decent standard of living, as measured by purchasing power, based on real Gross Domestic Product per capita adjusted for the local cost of living in purchasing power parity (PPP) terms in US dollars

Figure 2.5 is an example of a graph based on electricity, as a form of commercial energy, and the Human Development Index.

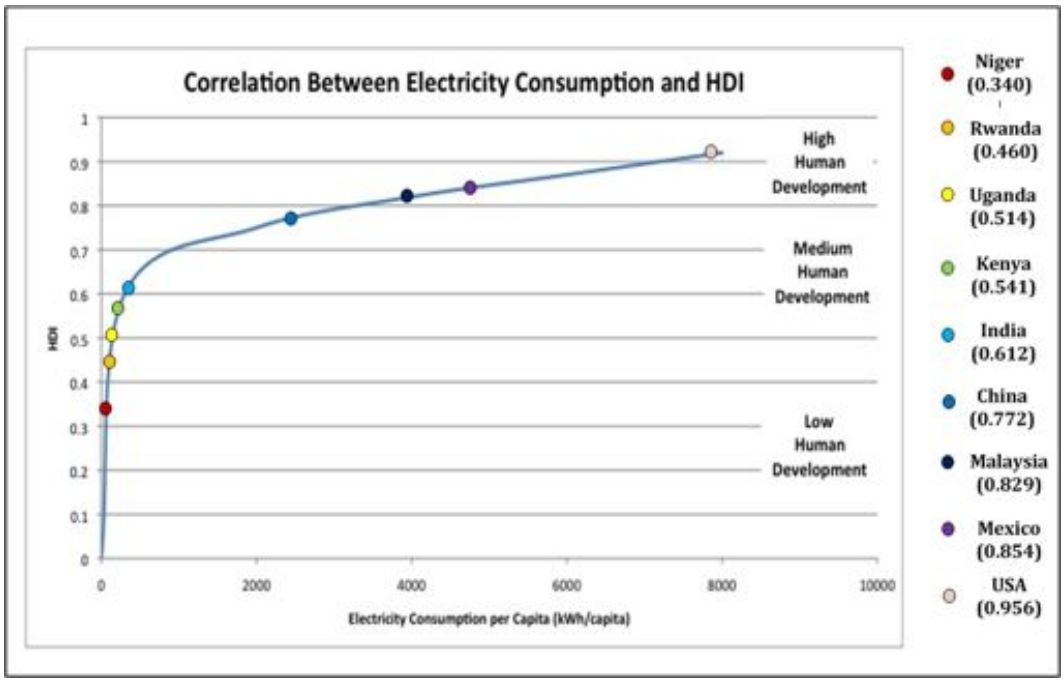

Figure 2.5: Macro level correlation between electricity and human development

[3]The Human Development Report (HDR) was first launched in 1990 with the single goal of putting people back at the center of the development process in terms of economic debate, policy and advocacy; bringing about development of the people, by the people, and for the people, and emphasizing that the goals of development are choices and freedoms. The report is available online: http://hdr.undp.org/en/

However, data shown on figure 2.5 has come to be used as a proof that electricity leads to improvement in human development. An example can be seen in the GEF-FAO workshop report which places the graph under the header Human development responds dramatically to initial electricity additions [White 2002]. [Shiu and Lam 2004] show that 21 separate studies on these correlations in the Asian region provide all possible conclusions: in some cases causal relationships were found to be bidirectional, in others, relationships were non existent, while some found causal relationships from increased modern energy or electricity consumption use to Gross Domestic Product (GDP) and others found the reverse.

Many macro-economic studies emphasize the impacts of modern electricity on industrialization which automatically focuses on large scale and electricity intensive industries rather than the impacts of modern electricity access on small enterprises. [Prasad and Dieden 2007] specifically study the impacts of grid extension on the establishment of small enterprises in South Africa. This study, which is based on nationwide survey data for the number of micro-enterprises using and those not using electricity, attributes the growth of micro-enterprises to the increase in electricity uptake in electrified areas and to the extension of the grid into new areas. However, it provides no information for understanding the factors that motivate the establishment of micro-enterprises and the choice whether or not to take up electricity, and whether the electricity activities are out of opportunity or out of necessity. Further, comprehension of how grid access may have contributed to establishment of enterprises is lacking.

At the local level, research in the field of electricity access for income generation shows consensus on improved opportunities, but that the evidence is often anecdotal [Fluitman 1983; Rogerson 1997; Fishbein 2003; Meadows 2003; Ramani and

Heijndermans 2003], or measured by tracking use of electricity before and after an intervention, rural electrification projects, rather than the impact on poverty itself [Barnett 2000].

Understanding how and under which circumstances or conditions electricity supply does lead to income generation is essential for the identification of complementary conditions, which may or may not be influenced through targeted interventions. Such understanding can be used in policy and projects for energy policy and rural development or poverty reduction, as it facilitates choices with regard to rural electrification, justification or targeting of financial support with the objective to achieve poverty reduction, and the identification of interventions to contribute to such impacts. The lack of comprehension of the conditions, both regarding context factors, and characteristics of entrepreneurs, has led to recommendations that a large range of conditions need to be in place before energy can have an impact on income generation [UN, 2002;UNEP, 2005; IDA, 2005] .

Progress toward providing greater access to modern energy has been slow due to a combination of interrelated circumstance. These include low-income levels among the un-served population; lack of financial resources for service providers to build the necessary infrastructure and reduce first-cost barriers to access; weak institutional, financial and legal structures that could otherwise encourage private investment; and lack of long-term vision and political commitment to scale up. At the United Nations Millennium Summit in September 2000, world leaders place development at the heart of the global agenda by adopting the Millennium Declaration from which the Millennium Development Goals (MDGs) were later extracted. The MDGs provide concrete, time-bound objectives for dramatically reducing extreme poverty in its man dimensions by 2015.

This research provides a linkage with the first goal which is to "eradicate extreme poverty and hunger" by showing the impacts of electricity access on increased income generation. Data collected will determine whether some circumstances or complementary inputs are found to have more influence, or form a stronger condition for positive impacts of electricity on income generation than others. As this research focuses on impacts of electricity access on the micro-enterprise, the areas for fieldwork have been selected where the quality electricity access is poor and that would conceal potential positive impacts of electricity access. Indications of the influence of access to electricity are provided through the sampling method. [4]

Figure 2.6: The difference of electrification between Europe and Africa is clearly seen in this photo taken by NASA. Africa with over 1 Billion people is poorly lit overall, and the brightest areas are the most urbanized, not necessarily the most populated. [NASA 2008]

[4]Meeting the targets of MDG 1 is a shared responsibility of rich and poor nations. Strategies for reaching the MDGs must by tailored to individual countries, but certain general elements are critical for success. Access to electricity is a key factor for promoting social progress and economic growth both of which are closely linked to sustainable reduction of poverty. Lack of access to affordable, reliable, safe and environmentally friendly energy is a serious barrier to sustainable development. This has serious implications for Africa which displays the lowest per capita consumption of electricity with an average of approximately 400 kWh per capita per year in the Sub-Saharan region. [Blyden et. al. 2008]

2.4 Power Generation and Distribution in Uganda

Like any other country, the energy sector plays a central role in the economy. Energy is the engine for economic growth and development, and a vital input into all the productive and social sectors of the economy. The sector is a major component of a country's infrastructure and supports economic and social development. It also contributes significantly to financing public expenditure.

Uganda's energy sector, like most other sectors of the economy is largely informal and under developed. It is characterized by a very low level of consumption of total modern energy is estimated at 2 toe per capita, one of the lowest not only in the sub-Saharan Africa but also in the world. There is over dependence on low-grade forms of energy especially traditional biomass fuels which accounts for more than 96% of the total energy consumption. The level of electrification is very low and only about 8% of the entire population are connected to national grid. In rural areas, where more than 85% of population lives, only about 1% are connected to grid electricity, while the remainder comes from diesel generators, batteries and solar photovoltaic [MNR, 2006].

Meeting the energy demand of a growing economy on a sustainable and efficient basis and improving the living standards of the people is a priority of the Ugandan government. The main challenge in the energy sector, therefore, is how to develop Ugandas considerable electric potential. The overall policy objective of Government for the energy sector, as stated in the ministrys policy statement, is to continue to improve the quality and quantity of energy supplies at least cost to the national economy, while also promoting efficiency and conservation of energy resources [MNR, 1996].

In general, the benefits of increased generating capacity can be measured along two different dimensions. First, increased generating capacity forms the basis for an expansion of the total supply of electricity. Secondly, since electricity cannot be stored, increased production capacity implies that higher demand can be accommodated at any given point in time, and the need for rationing of demand at peak hours is reduced.

For a long time, Uganda's hydropower generation from the Owen Falls Dam was the sole source of grid electricity. Whereas the installed capacity of the complex is 380 MW (180 MW at Nalubaale and 200 MW at Kiira power plants), the effective capacity of the complex has been as low as 100 MW in 2004/2005, and is up to around 140 MW today. This decline is due to the reduced level of Lake Victoria as a result of a drought in the region since 2003. As a consequence, Uganda has suffered chronic power shortages since 2005. Total electricity generation has increased rapidly over the last few years with an annual growth rate in electricity generation of 8.2% between 1998 - 2008, as compared to 3.8% between 1992 - 1998. The increase in generation can be understood as a result of the interplay between a number of factors demand, increased production capacity and the development of electricity prices.

The following plot shows the electricity production over a period of 19 years. It is quite evident that there has been an increase in generation and then drops due to several reasons such as political turmoil, civil strife, economic decline, reduced water levels of Lake Victoria and many others.

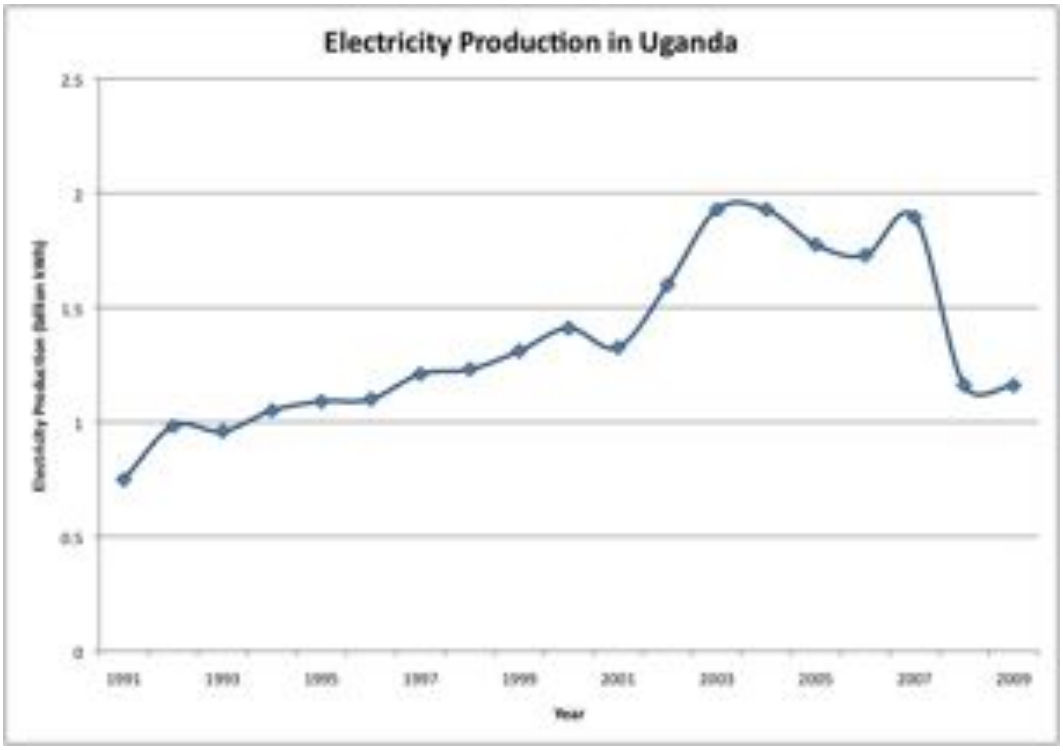

Figure 2.7: Electricity Production Showing Growth and Decline Over the Years [World Bank 2009a] Electricity Production: This entry is the annual electricity generated expressed in kilowatt-hours. The discrepancy between the amount of electricity generated and/or imported and the amount consumed and/or exported is accounted for as loss in transmission and distribution.

Going by the definition of energy poverty as "the absence of sufficient choice in access to adequate, affordable, reliable, quality, safe and environmentally benign energy services to support economic and human development" [UN MDG, 2009], it is apparent that there exists energy poverty at all levels of consumption in Uganda, particularly in the rural areas. If economic prosperity is to be achieved, sustained and standards of living for Ugandans improved, a paradigm shift in policy and planning for electricity supply and consumption is necessary. In the past, electricity planning has emphasized on addressing the supply side (primarily for commercial use) more than the demand side. The approach has tendered to favor the urban population while marginalizing the needs of the majority of the population, who live in rural areas and under the poverty line.

At present, there are approximately 400,000 connections to the electricity grid in Uganda. This is an increase from about 150,000 in 1999. Umeme is the principal power distribution company in Uganda. Formerly state-owned, Umeme's network covers a significant proportion of Uganda and includes 230,000 poles and 17,000 km of overhead cable. A World Bank study states, "No more than 7% of the total population in Uganda can afford unsubsidized electricity. It is unrealistic to think that more than a fraction of the rural population could be reached by a conventional, extend-the-grid approach. A more promising course is to rely instead on 'alternative and non-conventional' approaches to electrification." [Worldbank, 2007]

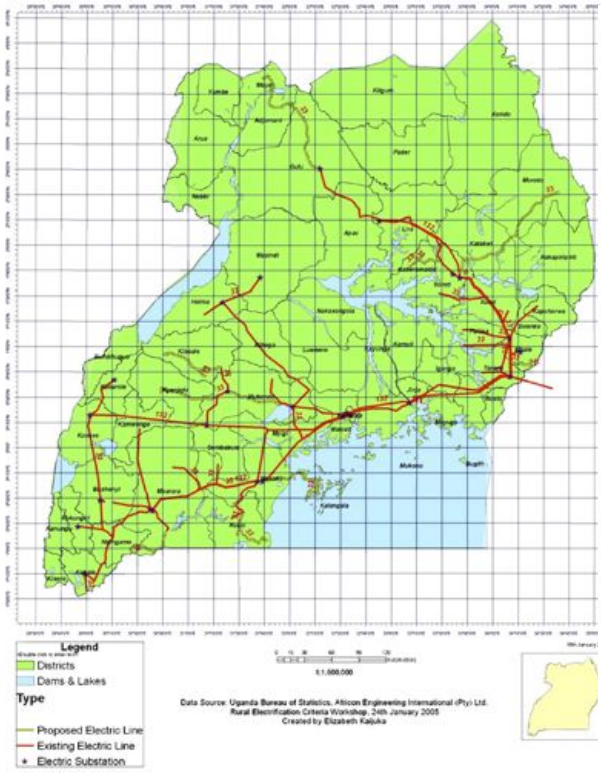

Figure 2.8: The electricity grid/transmission network in Uganda including proposed extensions [Kaijuka, 2007]

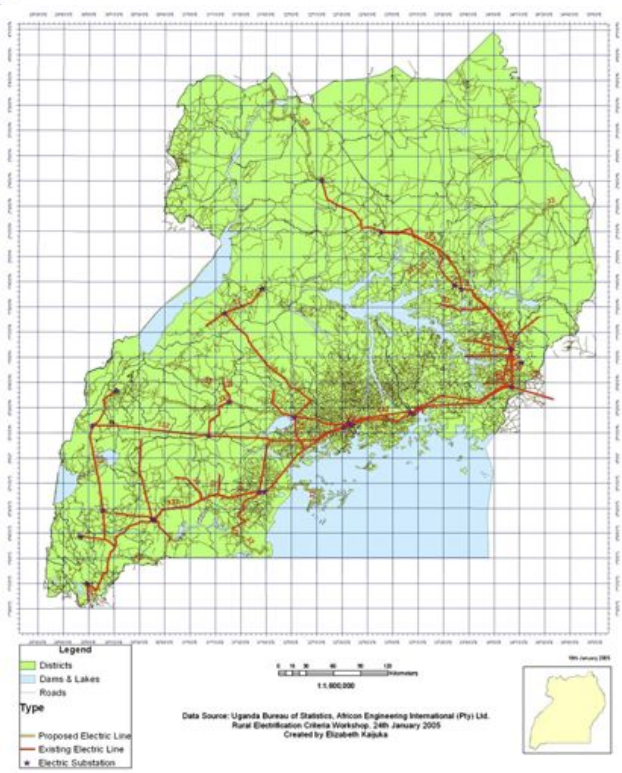

Figure 2.9: The electricity grid roughly follows the road network; under full coverage, they should ideally match [Kaijuka, 2007]

The continuous demand for electricity exceeds actual consumption, hindered by limited supply. The situation is exasperated further by recurring load-shedding imposed almost on a daily basis on urban consumers, mostly those in Kampala, where the demand is greatest. Despite the rationing, tariffs are on the increase, thus forcing customers to pay more for a lesser service [UMEME, 2009]. With a goal to kick-start development, provision towards service providing institutions such as micro-enterprises should stimulate improved services and social welfare, thus attracting greater business opportunities, and less urban migration.

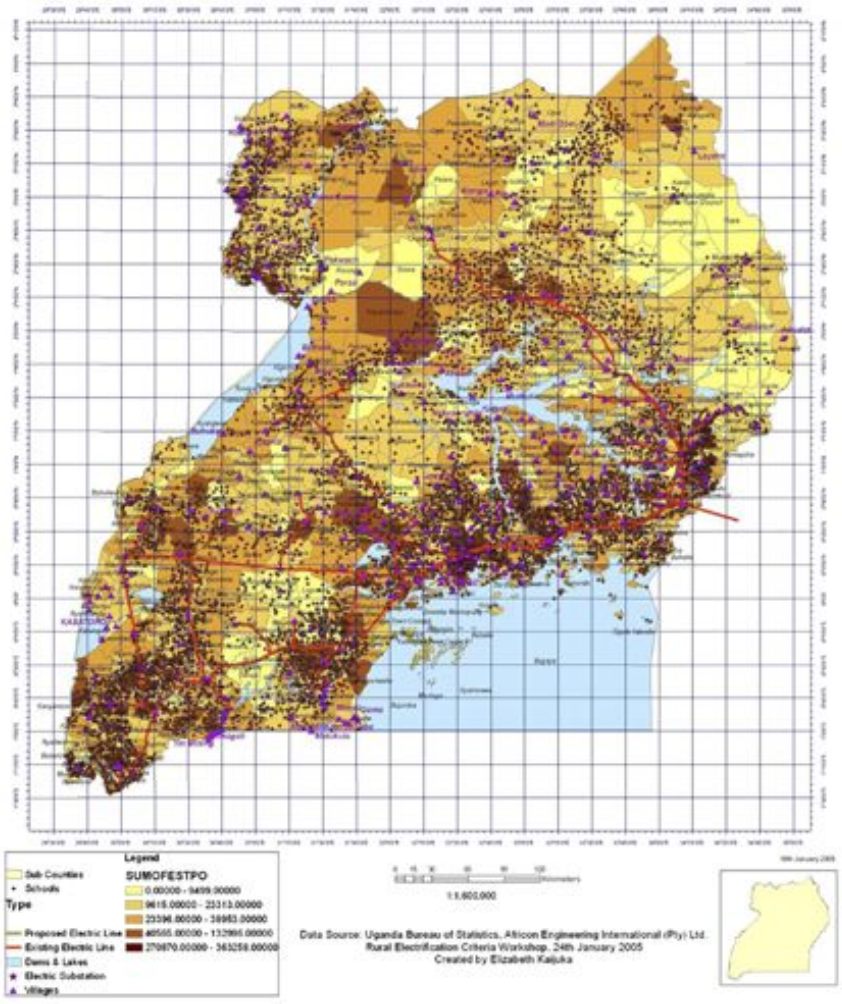

Figure 2.10: Population density is highest along the electricity grid; there are still many highly populated areas that are out of reach [Kaijuka, 2007]

2.5 Triangulation: Turning Qualitative into Quantitative Evidence

The significance of qualitative research comes from the role it plays in investigating the reasons and processes leading to certain results. Qualitative research has been described as work done to understand "meaning that is socially constructed by individuals with their world. The world, or reality, is not the fixed, single, agreed-upon, or measurable phenomenon that is assumed to be in positivist, quantitative research." [Merriam 2002] In this research, data collection methods include field notes, journals, semi-formal interviews surveys and interviews. Although large volumes of data are collected, drawing conclusions from a wide range of information often becomes a challenging task as experienced in this research.

Many recent advances in understanding have been achieved by deriving quantitative evidence from qualitative evidence, using the two dialectically, and indexing them against other quantitative findings from the same population. In so doing, one can use the triangulation method extending it to many apparently qualitative sources. Triangulation involves the careful reviewing of data collected through different methods in order to achieve a more accurate and valid estimate of qualitative results for a particular construct.

The idea of triangulation is associated with measurement practices in social and behavioral research. An early reference to triangulation is in relation to the idea proposed by [Webb et al. 1966], suggesting, "once a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced. The most persuasive evidence comes through a triangulation of measurement processes."

Sometimes triangulation is taken to include the combined use of quantitative and qualitative research to determine how far they arrive at convergent findings. For example, a study in the United Kingdom by [Hughes et al. 1997] on the consumption of designer drinks by young people employed both structured interviews and notes from the field work. The two sets of data were mutually confirming in that they showed a clear pattern of age differences in attitudes toward these types of alcoholic drinks. Qualitative research is inherently multi-method in focus and the use of triangulation reflects on an attempt to secure an in-depth understanding of the question at hand. According to [Denzin and Smith, 1998], triangulation provides several alternatives of data validation. The combination of multiple methods, empirical data, perspectives and observations in a study, is then best understood as a strategy that adds rigor, breadth and depth.

Data collection for case studies can rely on several sources, of which no single source has complete advantage over all the others. In fact, the various sources are highly complementary, and therefore a good case study will want to use as many sources as possible. Taking the example of South Africa's Electrification Programme, with collaboration with the president, stated the policy goal of universal access to electricity by 2012 [Mbeki, 2004]. This goal requires a significant adjustment of annual connection targets and electrification budgets, based on accurate knowledge of the number of electrified and non-electrified households in South Africa. Published data on the state of electrification, however, varies widely, with reported proportions of households electrified in 2005 varying from 57% to 80% [Marquard, 2007]. The use of a triangulation method has been in place through out the data collection, applying several different methods and combining them to reduce uncertainties. A statistically derived indication of the proportion of households electrified is published

in Stats SA's annual household surveys and national census, which report the number of households in South Africa that use electricity for lighting. As lighting is typically the most basic application of electricity in a household, statistics on its utilization are taken as an indication of the households electrified [NERS, 2003]. A second data set is obtained from the 'Electricity Supply Statistics' report which identifies the number of domestic electricity customers in South Africa. The Department of Minerals and Energy base the electrification data in these reports on data submitted to it on a monthly basis by Eskom (South Africa's primary utility company), municipalities and non-grid service providers licensed to distribute electricity, in a format prescribed by the Division of Revenue Act [NERS, 2005]. Eskom's annual reports also publish electrification data, but these relate only to connections made by Eskom and therefore do not reflect the state of electrification in South Africa as a whole. A combination of both qualitative and quantitative sources enables this data to be more accurate and provides validation.

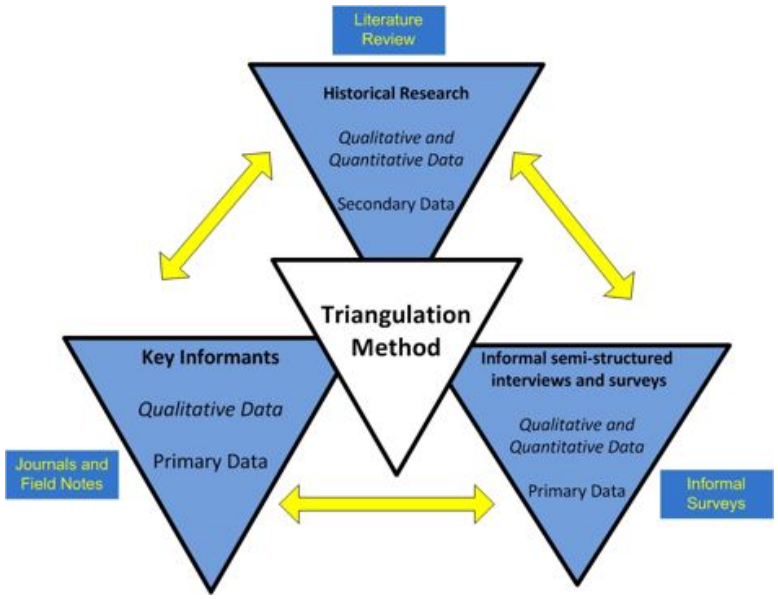

Figure 2.11: Data Triangulation Method Showing Each Method Used for the Specific Triangles

In my research, I use the method referred to as data triangulation, which entails

gathering data through several sampling strategies, so that slices of data at different times and social situations, as well as on a variety of people, are gathered. As seen in the diagram, I use journals and field notes to gather data from key informants which include general customers, government officials such as chiefs, electricity production managers and the like; semi-formal surveys and interviews are then used to collect data from the entrepreneurs. Both those sets of data are then used to compare with that historical data.

CHAPTER III

Micro-Enterprises in Uganda

3.1 Introduction

Uganda has progressed well in many of the economic and social indicators over the past decade as a consequence of the policy and institutional reforms undertaken within the context of the Ugandan Government's Poverty Eradication Action Plan (PEAP) [5]. However, despite this progress, the country's competitiveness when compared globally and regionally remains low. Recent evidence shows that Micro, Small and Medium-Sized Enterprises (MSMEs) [6] form the bulk of Uganda's private sector [UBS, 2008]. If Uganda is to become competitive through growth of the private sector, more attention must be paid to addressing the key bottlenecks to MSME growth and competitiveness.

This research is undertaken to better understand access to electricity by off-grid micro-enterprises; to identify the main sources of electricity used by the micro-enterprises; assess the effectiveness of the current access framework and mecha-

[5] The PEAP provides an over-arching framework to guide public action to eradicate poverty. It has been prepared through a consultative process involving central and local Government, Parliament, Donors and Civil Society. In order to achieve middle-income status, Uganda needs to industrialize by enhancing its competitiveness. Industrialization in Uganda will depend on using the resource base and hence on equipping farmers to understand the technical and quality requirements of commercial production. Government will therefore ensure the provision of public goods to support both agriculture and industry. In order to reverse the recent marked increase in inequality, Government will aim to increase the ability of the poorer households to participate in economic growth through self-employment inside and outside agriculture and wage employment.

[6] Enterprises qualify as micro, small and medium-sized enterprises (MSMEs) if they fulfill the following criteria in headcount: medium sized < 250, small < 50 and micro < 10

nisms; and to make recommendations for scalable sustainable solutions to support the growth of the micro-enterprise. Micro-Enterprises have been defined by the Uganda Bureau of Statistics (UBS) to mean firms/small businesses that have 1-20 employees. Using a stratified random sample [7], 135 micro-enterprises are interviewed. This research focuses on the 56 micro-enterprises that responded to all questions and had some form of access to electricity other than a connection to the grid.

The Republic of Uganda is a landlocked country in East Africa. It is bordered on the east by Kenya, on the north by Sudan, on the west by the Democratic Republic of the Congo, on the southwest by Rwanda, and on the south by Tanzania. The southern part of the country includes a substantial portion of Lake Victoria, which is also bordered by Kenya and Tanzania. Currently, 51% of the population of the country lives slightly below the poverty line (see definition in list of terminologies) and is currently subject to a severe food crisis. Uganda is home to many different ethnic groups, none of whom forms a majority of the population. Around forty different languages are regularly and currently in use in the country. English became the official language of Uganda after independence. Swahili, a widely used language throughout eastern and central east Africa, was approved as the country's second official national language in 2005,[Constitution (Amendment) Act of 2005] though this is somewhat politically sensitive. The current estimated population of Uganda is 32.4 million. Uganda has a very young population, with a median age of 15 years [UBS, 2009].

Three districts (Kabarole, Kamwenge and Kyenjonjo) in Western Uganda are selected for this research. Centralized around Fort Portal, an important market town, the area is situated between the Rwenzori Mountains, Kibale National Park and

[7] A method of sampling, which involves the division of a population into smaller groups, known as strata. In stratified random sampling, the strata are formed based on their members sharing a specific attribute or characteristic. In this research, the common attribute is those that do have access to grid electricity.

Queen Elizabeth National Park. This spectacular town overlooking the mountains of the moon is the seat of both the Kabarole district and the Toro kingdom. The towns surrounding it are very rural [8], with very poor infrastructure and are difficult to access especially during the rainy season. From the sample, eleven towns are selected for this research, providing several business categories for each town. Figure 3.1 shows the different towns distributed in three districts.

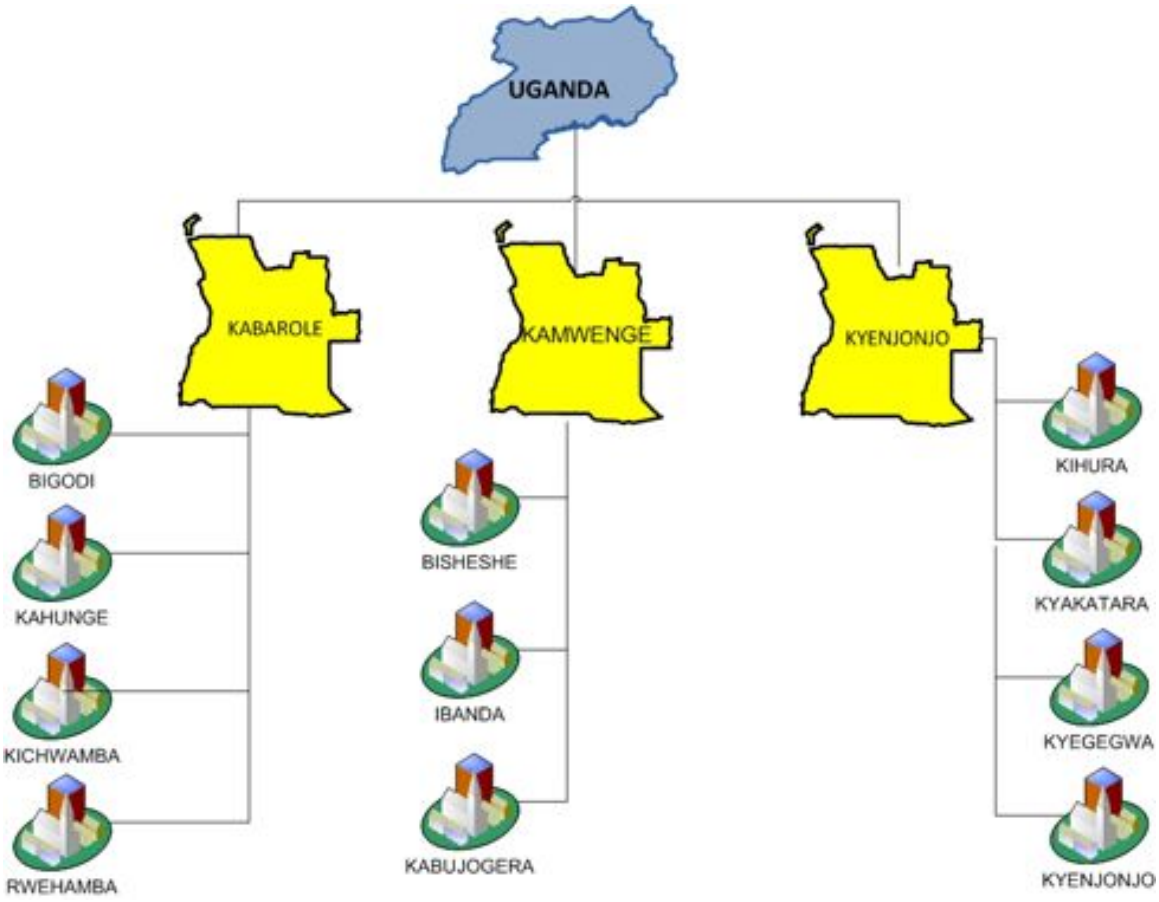

Figure 3.1: Schematic Diagram of theVillage Towns in the Three Districts of Western Uganda

[8]Rural in this case refers to a locality outside of areas that are administratively managed by urban authorities. Rural areas are relatively deprived in terms of modern energy infrastructure. They are not connected to grid electricity. Rural areas are sparsely settled places away from the influence of large cities and towns. They are remote from the national grid and have no chance of accessing the grid in the near future. Some of the towns may roughly be close to a grid connection (30 or more kilometers) but even then due to poverty issues cannot get connected.

The categories and number of micro-enterprises interviewed is as follows, as shown in the table as well as the map in the figure below:

Category	Number Interviewed
Bar	7
Barber	7
Battery Charging Station	3
Cellphone Charging Station	11
General Store	11
Pharmacy	2
Restaurant	2
Tailor	6
Video Hall	7

Table 3.1: List of Business Categories and Number of Micro-Enterprises Interviewed

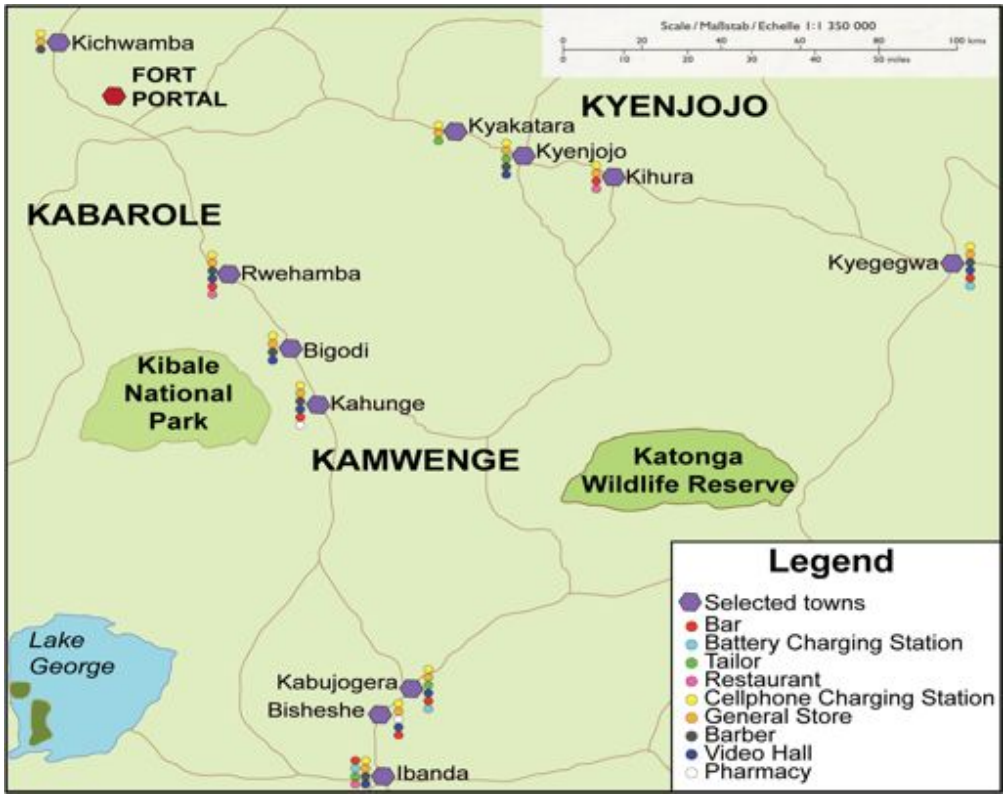

Figure 3.2: Distribution of Micro-Enterprises in the Rural Western Uganda.

Although rurality, especially in developing countries, is associated with agriculture as the primary means of income generation, the role of non-farm income generation is increasing [Liedholm and Mead, 1999; Rigg 2006]. [9] Micro-enterprises contribute greatly to the economies of all countries, regardless of their level of development. In 2001, Uganda was estimated to have approximately 1 million enterprises classified as MSMEs, forming 90% of Uganda's private sector. In Uganda, MSMEs employ approximately 1.5 million people, 90% of total non-farm private sector workers. The business sector, which is dominated by micro-enterprises, only contributes less than 20% to the GDP. From 1997 to 2006, the manufacturing sector's annual growth rate was only 1.3% [UBS, 2008]. The sector's efficiency has been decreasing, and its technical efficiency [10] is much lower (that is, 0.19) than that of manufacturers in Cameroon, Ghana, Kenya, and Zimbabwe [Gauthier 2001].

Figure 3.3: Typical Micro-Enterprise in Rural Uganda

[9] Empirical research shows that non-farm income including remittances has a similar or even higher contribution to rural household income, with findings at 40% - 60% of the households in South Asia and sub-Saharan Africa [Ellis and Biggs 2001] and 58% in India, and 60% - 80% in six African countries and increasing by over 50% over the two decades since the 1980s [Rigg 2006].

[10] Technical efficiency (using stochastic production frontier models) is the ratio between actual and potential output [Soderbom and Teal 2004b; Gauthier 2001].

Micro-enterprises represent one of the most viable vehicles for sustainable grass-roots economic growth. Attention needs to be focused on identifying how best to support such an important activity, i.e. the micro-enterprises, enabling them to have a catalytic role in the development process by creating jobs, reducing poverty, generating tax revenue and, above all, enhancing household incomes.

This study investigates both the qualitative and quantitative impacts of off-grid electricity access on the growth of the micro-enterprises in the selected region. Observations are made and questions asked to elicit data on the entrepreneur and the business in general; the products and services offered, including number of customers and sales; the methods of generating and accessing electricity; the cost of accessing electricity; the different uses of electricity; and the constraints faced in the process. Using this criterion, the selected micro-enterprises provide a comparative assessment of the impact of electricity on the productivity of micro- enterprises. The questions asked are categorized in the following sections:

- Micro-Enterprise Information:
  - *Name of the Entrepreneur*
  - *Age*
  - *Sex*
  - *Business Name*
  - *Length of Ownership*
  - *Daily Operating Hours*
  - *Number of Employees*
- Product and Services:
  - *Product and/or Services Provided*
  - *Buying Price (if product)*
  - *Selling Price (applies to both products and/or services)*
  - *Quantity sold per day*
  - *Number of customers per day*
  - *Daily Operating Hours*
  - *Number of Employees*

- Electricity Generation:
  - *Electricity Generating Equipment, for example, diesel generator*
  - *Cost of electricity generating equipment*
  - *Fuel Consumption per day*
  - *Cost of fuel, or cost of battery charging*
  - *Transportation Cost (what it takes to either transport the fuel or the battery)*
  - *Distance Traveled*
  - *Frequency of fuel purchase or battery charging*
- Electricity Use:
  - *Electricity Use - services that use electricity*
  - *Electricity Appliances, for example, cell phone chargers*
  - *Wattage*
  - *Number of hours used for each appliance*
  - *Cost of electricity appliances*
- Restrictions and Other Comments:
  - *Weather and Infrastructure Restrictions*
  - *Cultural Restrictions, for example how late they are open, role of women*
  - *Capital Access and the Willingness-to-Pay factor*
  - *Other comments*

I find that introduction of modern technology, for example, the use of a newer battery, increased the productivity of the micro-enterprise. In focusing on cell phone charging stations and general stores (which were both found in every village-town in the data set), there is an increase in the number of customers as recorded during the typical visits. This also indicates a growth in sales during the periods of field-work conducted. Both also indicated an increase in the use of electricity as well as introducing new electricity appliances in selected cases. These are discussed in detail later in this chapter. [11]

[11] It is important to note that the visits were not coordinated systematically so the data could not be analyzed in quantitative detail. The numbers provided later in this chapter are approximates.

3.2 The Sources Electricity for Micro-Enterprise Use

Access to electricity services for everyone is a reasonable goal for global society, with development benefits very clear. There are many obstacles that would need to be overcome and no one single solutions fits all. Today's forecasts would require huge power-infrastructure investment in developing countries in the coming decades [Tester, 2005]. The proportion of the global population to be connected will rise and higher capacity and reliable supply needed. In parallel, such improvements allow for industrial (primarily agricultural in Uganda) expansion, increased productivity and economies to grow. However, looking at absolute figures, the number of people relying on traditional fuels will remain at an almost constant level. Unless policies are changed and scalable sustainable solutions for generating off-grid electricity are implemented, progress will not reach the most deprived. Starting the climb up the energy ladder becomes difficult [WEA, 2002].

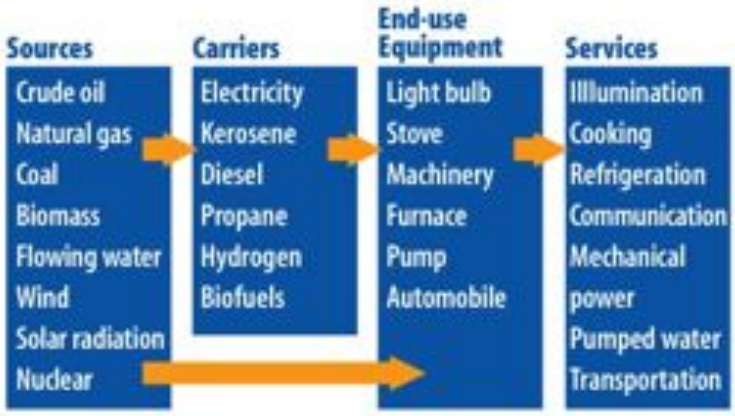

Figure 3.4: Climbing the energy ladder towards more modern methods is a challenge that most poor people in developing countries face if they are to improve their overall standard of living. [WEA, 2002]

Energy models were first developed in the 1970s as a result of the increasing availability of the computer and the first oil crisis. Most of the energy models were built and used in industrialized countries, so that the assumptions about energy systems of developing countries were mainly based on experiences from those in industrialized

countries. It was therefore assumed that the energy systems of developing countries would behave like those of the industrialized ones [Shukla, 1995]. For energy modeling, trends for developing countries were derived from those of industrialized countries and extrapolated to low-income ranges. This approach sounds great but may nevertheless result in models biased towards industrialized countries, possibly leading to incorrect interpretation of energy systems of developing countries.

The push to privatize electricity generation and distribution in developing countries during the 1990s has, in some ways, exacerbated the problem of reaching those living in off-grid areas. Private distribution utilities, driven by bottom-line considerations, have concession contracts that limit their service obligation to households located a relatively short distance from the grid. Utilities have little incentive to connect customers located beyond this limit because unit connection costs are higher and customers, who are generally poorer, can only be charged tariffs that are below the marginal cost of service.

Most poor households in developing countries lack access to modern energy, in this case, electricity. They instead rely on traditional biomass fuels like crop waste, dung, and wood to meet their energy needs. The order of fuels on the energy ladder corresponds to their efficiency and cleanliness at the end use. Although modern energy tends to be more costly - at least from a monetary perspective - than traditional methods, it provides people with a far greater opportunity for income generation for the micro-enterprise.

Determination of power output for the different off-grid electrical technologies proves to be difficult in most of the cases interviewed for several reasons, primarily because there is little to no data on the actual electricity generating equipment or on the electricity appliances. Despite the strong efforts made by researchers and utility companies to decouple the concepts of electricity sales measured in pennies per kilowatt-hour from fee-for service monthly payments, many of the rural customers

are paying high rates for basic services, with costs some times taking up over half of their daily income. There are two major stand-alone electricity sources that are considered at the micro-enterprises:

- *Electricity Generation System*: converts heat energy into kinetic energy and then into electric power, or directly into electric power (in the case of Solar PV)
- *Electricity Storage System*: Rechargeable lead-acid batteries that store electricity to provide energy on-demand, a controller that manages the storage to the battery and deliver power to the load, and the structure required to mount or install the system

In this research, the most common stand-alone source of electricity at the micro-enterprises is automotive (car) batteries (stored charge); commonly transported to specific charging stations where they are charged and then used again. Figure 3.5 shows the graphical distribution of the electricity generating and storage equipment in the region studied while figure 3.6 shows a map with the distribution of the electricity generating and storage equipment.

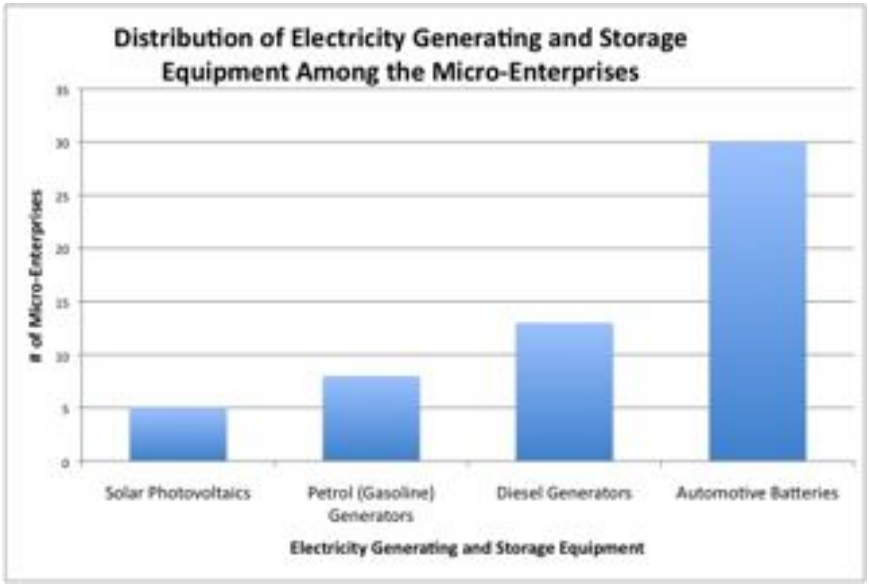

Figure 3.5: Graphical Distribution of Electricity Generating and Storage Equipment

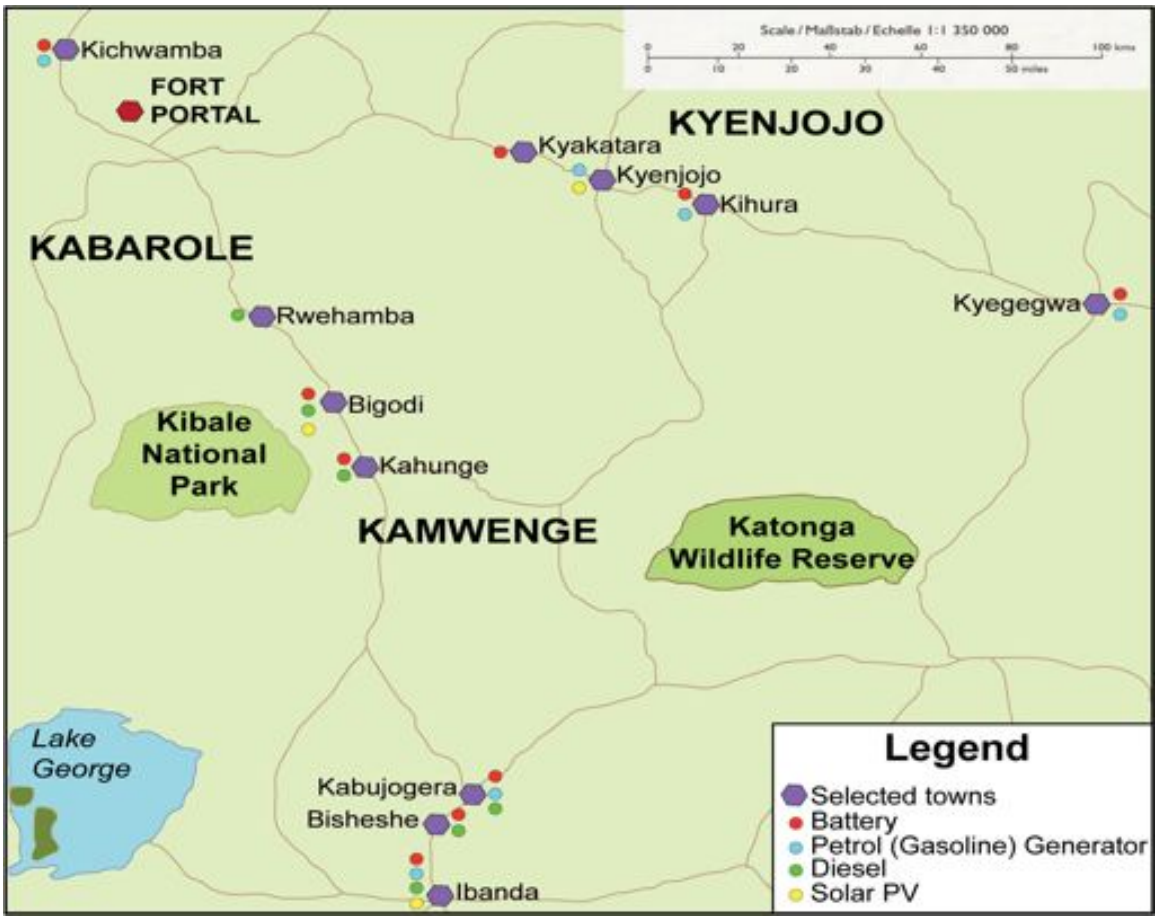

Figure 3.6: Map Distribution of Electricity Generating Equipment

Regions and communities without grid electricity often suffer from extreme poverty, limited freedom of choice and opportunities of accessing electricity, and very high costs of access. Raising capital to meet those needs often becomes a task that is difficult to deal with both for the government and the local people. Distortion of commercial incentives often worsens an already difficult situation, and in many cases, this is combined with a policy environment and institutional structure that is not conducive to private sector investments.

3.2.1 Solar Photovoltaic Systems

Solar power is probably the cleanest and most viable form of energy available and it can be used in several forms. The technology and the systems are becoming smaller, more compact and easier to install than when they were first created and used. Solar power systems work by converting some of the energy in sunlight into a clean form of electricity. The PV cells consist of a positive and a negative slice of silicon placed under a thin slice of glass. PV cells are made of special materials called semiconductors such as silicon, which is currently used most commonly. Silicon has some special chemical properties, especially in its crystalline form. An atom of silicon has 14 electrons, arranged in three different shells. The first two shells which hold two and eight electrons respectively, are completely full. The outer shell, however, is only half full with just four electrons. A silicon atom will always look for ways to fill up its last shell, and to do this, it will share electrons with four nearby atoms. That is what forms the crystalline structure which is important to this type of PV cell.

Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor thus the electrons become loose, allowing them to flow freely. PV cells also all have one or more electric field that acts to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is a current, and by placing metal contacts on the top and bottom of the PV cell, one can draw that current off for external use. This gives Direct Current (DC) [12] electricity though, and it must be passed through an inverter to be converted into an Alternating Current (AC) [13] used to power electrical appliances. Figure 3.7 shows how a basic solar system works.

[12] Direct current (DC) is the unidirectional flow of electric charge. In DC, the electrons flow steadily in a single direction, or "forward". Direct current is produced by such sources as batteries, thermocouples, solar cells, and commutator-type electric machines of the dynamo type.

[13] Alternating current (AC, also ac) is the movement (or flow) of electric charge periodically reversing direction. In AC, electrons keep switching directions, sometimes going "forwards" and then going "backwards". Used generically, AC refers to the form in which electricity is delivered to businesses and residences.

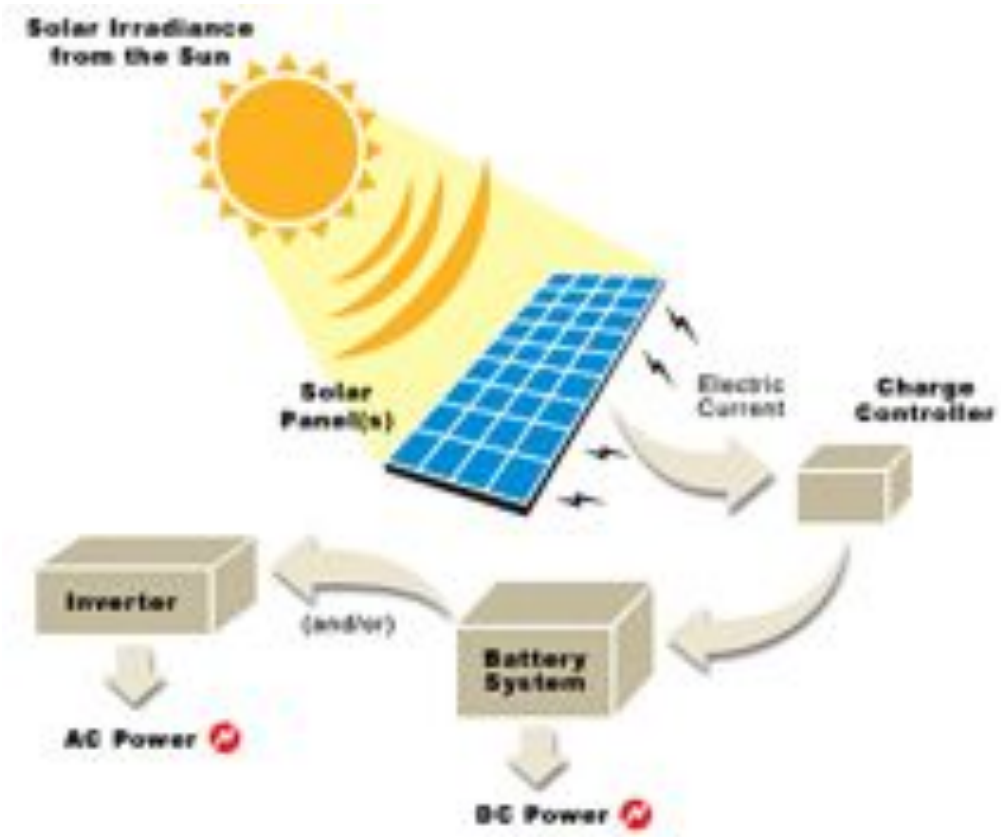

Figure 3.7: How solar systems work [Photo credit: Tmayhu, 2006 Courtesy of Photobucket]

The output of Solar Photovoltaic Systems strongly depends on the average diurnal solar radiation incident upon the module, which sequentially depends on the tilt and orientation. It is assumed that the standard tilted angle for the PV module is equal to the latitude of the location where the module is installed. This is the slope, which maximizes the annual radiation in the plane of the PV module and consequently its power output. The estimation of energy output annually then follows:

$$E = \eta W_p(\frac{Q}{Q_0})X365 \tag{3.1}$$

where η is the average system efficiency (battery, charge controller and loss in wiring); W_p is the peak capacity of the PV module; Q is the annual average daily solar radiation ($\frac{W}{m^2 day}$); Q_0 is the standard solar radiation (1000 $\frac{W}{m^2}$); and 365 represents the number of days per year.

The number of micro-enterprises that use solar PV systems in this study is only five out of the fifty six, approximately 10% which is somewhat representative due to the high cost of the modules and installation. Better technology through advanced materials can reduce the cost and improve both the performance and reliability of the system. Unfortunately, this is not the case in rural Uganda. The number of people trained to do such installations, with precision and understanding how to maximize output it typically unheard of in the region. Most technicians may have to travel as far as coming from Fort Portal (approximately 50km or more, depending on the village town). The five distribution of the micro-enterprises is as follows:

Village Town	**Micro-Enterprise**
Bigodi	Cell Phone Charging Station Video Hall
Ibanda	Bar
Kyenjonjo	Barber General Store

Table 3.2: Distribution of Micro-Enterprises Using Solar PV Systems

The modules installed are on a small scale, with very basic installations, most of which are not configured and optimized for maximum energy output. One of the systems studied (Video Hall in Bigodi) involved the use of a high-efficiency crystalline solar cell, a charge controller and a locally [14] made 24V 100 amp-hours (Ah) deep-cycle battery. [15] The battery then provides power for a simple video system containing of a VCR, a DVD and a TV. The battery is also used to provide lighting for the moments just before they start the showing and briefly after it is over.

[14]The term 'locally-made' is used loosely here representing the East Africa Community as one local entity rather than just viewing Uganda as the local entity. This is primarily because Uganda depends on most of it's products to come from Kenya and Tanzania because it is landlocked (no access to the Indian Ocean)

[15]Chloride Exide, East Africa's biggest and most reliable provider of solar and battery solutions, was established in Kenya in 1963 as part of the Chloride Group PLC in UK, with its core business as distribution of automotive batteries to end users. Chloride Group PLC UK, sold its interests to indigenous Kenyans in 1993, and CEKL became part of the NAS Group of Companies, with 100% share holding by Kenyans. CEKL has a countrywide network of 11 branches in Kenya. Chloride Exide Tanzania is a registered company in Dar-es-salaam, Tanzania, and has a branch in Arusha.

To calculate the usage of the appliances, we begin by the definition of power which is the rate at which work is performed or energy is converted. We follow simple electricity formulation:

$$P = VI \tag{3.2}$$

where P is the Power (Watts), V is the Voltage (Volts) and I is the current (Amperes). Once we know the Power, we then can calculate the Energy by taking the Power and multiplying it by the time (hours) that the appliance is used for

$$Energy(E) = Pt \tag{3.3}$$

We can therefore find the usage by taking the Energy (Wh) and dividing it by the Voltage (V) of the battery and this will give us the usage in Ampere hours (Ah).

$$Usage = \frac{E}{V} \tag{3.4}$$

For this system, the battery is usually sufficient to run the video hall for the a short period in the evening without draining it completely. Issues arise when there are football (soccer) matches. The length of the games, and the fact that other appliances such as speakers are installed and watching with lights on, to maintain order, because most people are probably drinking. The owner does not have a measuring device to know if the battery is charged or not, so relies on not running any other appliances until the time of the match. There have been cases where towards the end the battery would die and of course, the efficiency decreases over time.

Appliance	**Wattage (W)**	**Quantity**	**Duration Used (h)**	**Usage (Ah)**
Kyocera DVD	45	1	2	3.75
Kyocera VCR	35	1	2	2.92
Phillips 25" TV	250	1	4	41.7
CFL	25	3	4	12.5

Table 3.3: Electricity Appliances at Video Hall in Bigodi

In a brief interview/conversation with the owner, several factors are highlighted in regards to obtaining the equipment and usage:

Q: "How did you develop the idea of the video hall?"

A: *"I have an Irish friend who wanted to watch the football match and could not find anywhere to watch it nearby. He suggested to me that I start something like that but I had no finances to begin it. All the initial equipment (solar panel, charge controller, inverter and battery) was bought by him (the friend) from Kampala, then I hired a technician from Fort Portal to come and set it up. The rest of the equipment has been bought recently with the little profits that come from the business."*

Q: "How often have you had the system serviced?"

A: *"Why fix it if there's nothing wrong? I don't see anything wrong with it and so no need to fix it. Only thing is that the battery does not use acid* [16] *and the people here do not know how to work on it."*

Solar systems in the other towns follow a similar trend of installation and initial investment. A different case is the general store in Kyenjonjo (a growing and thriving town located on the Kampala-Fort Portal Road). The owner indicates that because of the constant traffic on the road, it made sense to have brighter lighting and be able to open later hours. The customers increased quickly using brighter lights compared to using a kerosene (paraffin) lantern.

"People in developing countries want a clean environment, but we are too poor to invest in systems like solar that are clean and reliable. It's not just a matter of charity or solidarity: It is self-interest. We are now sources of growth and importers of capital goods and developed countries services. We need improvement in capital, I could only afford a very small system, but would prefer something better." – Kyenjonjo Barber

[16] It is important to note that the subject did not realize that the battery is sealed so as to prevent the common practice of replacing the acid in it. In his perception, it just makes sense that the battery does not use acid, which is another indication on the lack of education as one of the barriers towards accessing and efficient use of electricity in rural areas

Small, simple, solar electric systems can be a part of the solution, increasing the quality of life, and are often at a cost that is less than what is presently being spent for the petrol, diesel and/or recharging of automotive batteries that must be lugged to the nearest battery charging station on a weekly basis or even more frequently. The success of solar systems in this areas depends not only on the competitive cost, but also on the human infrastructure needed to deploy and maintain the systems (even though we can loosely say that most solar PV systems are almost 'maintenance-free') for effective cost-effectiveness and reliability.

3.2.2 Petrol and Diesel Generator Systems

The internal combustion (IC) engine has been used for many decades in developing countries playing a very important role in providing off-grid power for rural communities. Many stand-alone units are used for milling, small-scale electricity production, water pumping, etc. They are readily available, off-the-shelf in most major towns and cities in a range of sizes to suit various applications. Generators work by changing mechanical energy to electrical energy. It can be done by spinning an armature (one of the electrical components of a motor that contains conductors) through a magnetic field. Generators are based on the principle of electromagnetic induction, which was introduced by Michael Faraday in 1831. This electromagnetic effect induces voltage or electric current into the moving conductors.There are two main types of IC engines defined by the type of fuel used; petrol (gasoline) or diesel. The petrol engine is widely used for small vehicles and light applications whereas diesel engines are more suited to continuous running for lengthy periods at higher load ratings and are therefore used more widely for stationary applications.

The combustion process in the petrol engine and the diesel engine differ in the following ways. In the petrol engine the petrol and air mixture is drawn into the cylinder, compressed (compression ratio ranging from 4:1 to 10:1), and ignited by a spark introduced by an electrical system. In the diesel engine, air alone is drawn

into the cylinder and is compressed to a much higher ratio (14:1 to 25:1) than in the petrol engine. As a result of this compression the air is heated to a temperature of 700 - 900 °C. Only then is a certain quantity of diesel fuel injected into the cylinder and the fuel ignites because of the high temperature. Hence the petrol engine is often referred to as the spark ignition (SI) engine and the diesel as the compression ignition (CI) engine. Secondly, there is the sub-division according to cycle type; the two stroke or four stroke cycle. This means that engines have an ignition phase on every revolution of the crankshaft or every other revolution.

Diesel generating sets come in a wide range of commercially available sizes, from about 5 kW up to 30 MW (30,000 kW). Petrol generator sets come in smaller sizes - from 500W up to several kW - and tend to have a much shorter lifespan (5000 hours running time) than their diesel counterparts. They are more suited to mobile, very small scale electricity needs [Tester et al, 2005].

There are two main costs to consider when discussing the generators - the investment cost and the running costs. For diesel systems the investment costs tend to be relatively low compared with renewable energy technologies such as solar photovoltaics, while the running costs will be high. Running costs will also vary widely as there are many factors which will determine the actual cost of the power supplied - generating capacity, load factor, efficiency, fuel costs, etc. It is worth bearing in mind that, in the long term, the fuel costs for a diesel or petrol engine will be high compared with the capital cost and this often causes problems where there are no guaranteed funds or income for fuel purchase.

The number of micro-enterprises that use fuel generator systems is twenty one out of the fifty six, approximately 40% almost half of the number of micro-enterprises. The distribution between those twenty one is such that eight use petrol (gasoline) generators and thirteen use diesel for fuel. With the exception of two generators (both diesel), all the rest were obtained as used equipment, or more like 'hand-

me-downs'.[17]. Tables 3.4 and 3.5 and figures 3.8 and 3.9 show the distribution of the micro-enterprises using petrol (gasoline) generators and diesel generators respectively.

Village Town	**Micro-Enterprise**
Ibanda	Bar
Kabujogera	General Store
Kichwamba	Barber
Kihura	Bar Restaurant
Kyenjonjo	Video Hall
Kyegegwa	Bar Battery Charging Station Video Hall

Table 3.4: Distribution of Micro-Enterprises Using Petrol (Gasoline) Generators

Figure 3.8: Petrol Generator

[17]Something (commonly used to describe an article of clothing) which is used and then passed along to someone else either free or at a very minimal cost.

Village Town	Micro-Enterprise
Bigodi	Barber
Bishese	Bar Cell Phone Charging Station Video Hall
Ibanda	Battery Charging Station Video Hall
Kabujogera	Bar Video Hall
Kahunge	Bar Battery Charging Station
Rwehamba	Bar General Store Video Hall

Table 3.5: Distribution of Micro-Enterprises Using Diesel Generators

Figure 3.9: Diesel Generator

3.2.3 Battery Systems

In the case of battery systems, the electricity is generated away from the site where the micro-enterprise is located and transported in a battery. Battery charging stations are a common business and are typically located roughly 10-20 km away from the micro-enterprise site.

A battery, by definition, consists of a group of two or more primary or secondary battery cells, which convert chemical energy into electrical energy. A portion of the chemical energy a cell produces is transformed into heat, and a portion into an electric current. A cell is just the working chemical unit inside a battery; one battery can contain any number of cells. A cell has three main parts: a positive electrode (terminal), a negative electrode, and a liquid or solid separating them called the electrolyte. When a battery is connected to an electric circuit, a chemical reaction takes place in the electrolyte causing ions (in this case, atoms with a positive electrical charge) to flow through it one way, with electrons (particles with a negative charge) flowing through the outer circuit in the other direction. This movement of electric charge makes an electric current flow through the cell and through the circuit it is connected to.

The specifications and ratings of batteries are vital in comparing different types of batteries and recognizing how they will perform in different situations. A battery's ampere-hour (Ah) rating is extremely useful in the analysis of battery usage. The ampere-hour rating is defined as how long a battery can operate when certain amperage is being drawn from it. The voltage of the battery is useful when determining what types of devices it can power based on what voltage that is required for the device.

An important consideration is how often batteries need to be charged. This translates into how long they will be able to power a device. Two factors come into play when considering how long a device can operate on a battery: the ampere-hour

rating of the battery and the current drawn by the device. A main consideration for the amount of current drawn by the device is how much resistance it has.

The amount of current drawn in amperes will be based upon the equation (3.5)

$$I = \frac{V}{R} \tag{3.5}$$

where I is the current (Amperes), V is the voltage supplied (Volts) and R is the resistance of the device (Ohms). Once the current is determined, the amount of time until discharge can be determined from the ampere-hours of the battery using equation (3.6)

$$h = \frac{rating(Ah)}{current(A)} \tag{3.6}$$

where h is the number of hours available for use in the battery, battering rating is in ampere-hour (Ah), and the current drawn from the circuit in amperes (A) and determined using equation (3.5). In this way it can be determined how long a charge on a battery can last, and therefore, how often it needs to be charged. A battery will lose its recharging ability over its life. This is addressed when dealing with the batterys state of charge and its state of health.

Approximately 55% of the micro-enterprises interviewed use automotive batteries (that are charged elsewhere) to power small electrical appliances such as lights, television, and radio. Most of the battery charging stations do not consider the above calculations when charging the batteries and most likely have faulty multimeters when measuring the charge of the battery. It is common to find that the batteries never get a full charge. Consequently, there are high rates of battery servicing, which often means dumping out the old sulphuric acid in a hazardous method, not to mention the lack of safety in the actual handling of the acid. My assumption is that the use of automotive batteries has discrete disadvantages to the entrepreneur that need to be determined on a local basis which is not a focus of this research. [18]

[18]The focus of this study did not cover the environmental impacts of the use of automotive batteries.

The distribution of the micro-enterprises using battery systems is as follows:

Village Town	**Micro-Enterprise**
Bigodi	General Store
Bishese	General Store Pharmacy
Ibanda	Barber Cell Phone Charging Station General Store Tailor Restaurant
Kabujogera	Cell Phone Charging Station Tailor
Kahunge	Barber Cell Phone Charging Station General Store Pharmacy Tailor
Kichwamba	Cell Phone Charging Station General Store
Kihura	Cell Phone Charging Station General Store
Kyakatara	Cell Phone Charging Station General Store Tailor
Kyegegwa	Barber Cell Phone Charging Station General Store Tailor
Rwehamba	Barber Cell Phone Charging Station Restaurant

Table 3.6: Distribution of Micro-Enterprises Using Automotive Batteries

Figure 3.10: An automotive battery setup

Figure 3.11: A battery system connected directly to a CFL

3.3 Electricity Use

From the perspective of the entrepreneur, the choice of access to electricity is made in relation to available alternatives. Therefore, in order to understand the decisions for the choice made, it is important to understand what the uses are. The perception of alternatives may be related to the physical presence of alternatives, or to more diffuse expectations which are influenced by entrepreneurs assets and motivations.

For the analysis of impacts of electricity access, it is useful to distinguish between the functions of electricity use within the micro-enterprises. This is an important distinction to make, as not all electricity services have the potential or are intended to contribute to income generation in the micro-enterprise. The electricity services have been categorized into three categories: lighting, entertainment (TVs and Radios) and micro-enterprise services [19].

Category for Electricity Use	**Number of Micro-Enterprises**
Electricity for Lighting	56
Electricity for Entertainment	14
Electricity for Other Micro-Enterprise Services	31

Table 3.7: Number of Micro-Enterprises based on the category of use

Table 3.7 provides an overview of how many micro-enterprises of the total sample of 56 micro-enterprises are making use of electricity for different categories of electricity services. Despite the fact that the 56 micro-enterprises have lighting as one of the main uses of electricity, 35 of them (about 63%) only occasionally remained open in the evening, with only fifteen regularly doing so.

The perceptions about electricity are also related to social status of the entrepreneur, which may form an implicit but strong argument to take up electric lighting regardless of economic calculations. The field research also showed, however, that having electric light or not is often not an outcome of a conscious or

[19] Entertainment consists of the use of media appliances such as TVs and Radios. Micro-enterprise services primarily consist of communication needs and refrigeration.

strategic decision made by entrepreneur. Firstly, 42 of the micro-enterprises run inside or right next to the entrepreneur's home (for instance cellphone charging stations are commonly a room in the home, or the general stores are typically the home with a window opening for the entrepreneur to conduct business), which in turn makes the access for the home and the micro-enterprise inseparable. Secondly, most entrepreneurs who do have electric lighting have some form of back-up light, usually a kerosene lamp or candles, for use when they cannot afford access to lighting.

An observation that most developed countries could learn from developing countries is the use of Compact Fluorescent Lamps (CFL). [20] Of the total number of micro-enterprises, 52 of them used CFLs, a 93% success rate; most of them leapfrogged the technology and never used incandescent bulbs. It is the hope that LED lamps will eventually replace the CFL due to their low energy consumption.

[20] A compact fluorescent lamp (CFL), also known as a compact fluorescent light or energy saving light (or less commonly as a compact fluorescent tube), is a type of fluorescent lamp. Many CFLs are designed to replace an incandescent lamp and can fit into most existing light fixtures formerly used for incandescents. Compared to general service incandescent lamps giving the same amount of visible light, CFLs use less power and have a longer rated life. In the United States, a CFL has a higher purchase price than an incandescent lamp, but can save over in electricity costs over the lamp's life time. CFLs radiate a different light spectrum from that of incandescent lamps. Improved phosphor formulations have improved the subjective color of the light emitted by CFLs such that some sources rate the best 'soft white' CFLs as subjectively similar in color to standard incandescent lamps. [Phillips, 2007]

3.4 The Economic Approach

Although we know that electricity problems are multidimensional, one critical unifying thread runs through all the proposed solutions - the economic factor. In many cases, when examining the case of the micro-enterprise in relation to access to electricity and the provision of electricity services, economic factors are at the heart of the decisions that at first sight appear non-economic. Underlying realities are surely mirrored in the decision that emerges from the methods to access electricity. The sociological character of the micro-enterprise and the entrepreneur also reflects the economic factors, whether they have the capacity-to-pay, the environmental conditions, possibilities of increased income and the adaptation of technology by the entrepreneur.

One of the principal achievements of economics has been in the development of a particular way of looking at the world and analyzing economic phenomena. The embodiment of this approach is theoretical economics. Methodologically, there is a great deal of commonality in the way economists approach problems even though their conclusions may differ. The theoretical models of economics have been studied for many years but it is important to note that from this study, output of a theoretical model is not reality and most basic economic models are difficult to apply due to several barriers as will be discussed in Chapter 4. Due to this fact, forecasting becomes a highly uncertain task as most of the entrepreneurs live on a day-to-day basis. [21] Validation of economic models by testing them against the measuring rod of the real world empirical data proves to be difficult because the entrepreneurs understanding of economics is limited and most operational costs are factored in with several other social factors, making it complex to define the variables.

[21] The differences between day-to-day life in developing countries and the U.S. are huge and can be very difficult for us to comprehend. Virtually everything what people own, what they do for a living, what they do in their leisure time, what they expect out of life for themselves and their children, the way they think about themselves and others, the things they take for granted, and more differs dramatically in rural Uganda versus a typical U.S. neighborhood. Most of the developing world's population are living in extreme economic poverty defined as living on less than $1.25 per day; thus planning for the future becomes a concept not easily understood. They mainly live on the basis of what I make today decides what I invest in tomorrow.

3.4.1 Cost of Accessing Electricity

Essentially, cost is the burden sustained in order to perform a certain activity, to carry out a certain production, to achieve certain goals. Total cost is in two main categories, fixed cost (the part of the budget that stays the same regardless of whether you produce a lot, a little bit, or even if you produce zero), and variable cost (the part that varies as you produce more or less. Producing more adds to Variable Cost. Producing less reduces it) Therefore, it is trivial to calculate to Total Cost,

$$TC(i) = FC + VC(i) \tag{3.7}$$

where TC is the total cost, FC is the fixed cost, VC is the variable cost and i is the variable for production.

In this study, the basic costs are categorized as follows:[22]

Cost Item	**Cost Category**
Electricity Generating Equipment	Fixed
Electricity Appliances	Fixed
Goods/Services in sales	Variable
Space (if rented)	Fixed
Space (if owned)	None
Fuel/Charge	Variable
Transportation	Variable

Table 3.8: Basic costs as viewed from the entrepreneurs perspective

There are many ways in which electricity has influenced growth in Africa. In this study, data from the sample shows that the two categories of micro-enterprises were common across all the towns interviewed: Cellphone Charging Stations [23] and General Stores [24].

[22]The cost calculations in this study are very similar to the basic costs that a family-run small shop pays in the U.S.

[23]Much of Uganda's population is not served by landlines (100k telephones for a population of over 30 million) and likely not be in the foreseeable future.Todays obvious choice for network deployment is wireless mobile networks. A single base station (which itself requires several kW) can provide coverage over 60km if the terrain allows. This results in mobile phone coverage in areas without grid electricity. The mobile phones are charged at stalls on the street. Essentially, you deposit your phone with the stall holder in exchange for a receipt detailing the unique identification numbers of both the phone and the battery, the phone is locked in the cupboard and after several hours can be collected fully charged.

[24]General Stores, often referred to as 'duka', a Swahili word for shop, are establishments that sell general merchandise needed by the locals on a daily basis. You find a range of items such as soap, milk, bread, sodas, candy, snacks, candles, mostly non-perishable goods. Usually, they also serve the purpose of the entrepreneurs home. Typically, they will take one room and stock it with some items, open the window and conduct business through the window.

Distinctive electricity access choices can be observed through analysis of both the categories. Much has been written about the cellphone revolution sweeping Africa and its potential to spur development. Uganda's ICT [25] Minister states that the number of wireless subscribers rose to 8.2 million at the end of 2008. The mobile penetration stood at around 25% [UBS, 2009]. Despite the growth in subscribers, there has not been an equivalent growth in access to electricity, thus the case for cellphone charging stations almost in every town. [26]

Town	**Equipment**	**Fuel Cost**[a]	**Transportation Cost**	**Frequency**[b]
Bigodi	Solar PV	0	0	0
Bishese	Diesel Gen.	25000	8000	2
Ibanda	Battery	12000	6000	3
Kabujogera	Battery	4000	2000	1
Kahunge	Battery	9000	4500	3
Kichwamba	Battery	5000	1000[c]	2
Kihura	Battery	3500	2500	1
Kyakatara	Battery	7000	1500	1
Kyegegwa	Battery	7000	0[d]	2
Kyenjonjo	Battery	10000	4000	4
Rwehamba	Battery	9000	3000	3

[a] While the amount of fuel consumed in liters was not given, it is easy to calculate it using the approximate costs of fuel.
[b] Frequency here is determined on a weekly basis
[c] Entrepreneur indicated that they often send a family member to walk the battery to the charging place and only estimates paying for the transportation maybe once a week
[d] There is a battery charging station within a very short walking distance

Table 3.9: Distribution of Cellphone Charging Stations showing each town and the associated costs of accessing electricity. The figures in the tables are estimates given by the entrepreneurs, some have accurate numbers that they document, while others just gave an estimate off the top of their head.

The general stores have approximately the same costs for access as the cellphone charging stations, especially for those using battery systems. [27] The question of operating costs such as wages, maintenance of equipment, advertising and the like is not addressed in this research because the data is difficult to attain for micro-enterprises. Most of the micro-enterprises hardly keep any records of expenses they incur, bookkeeping being a somewhat foreign concept.

[25] Information and Communication Technologies
[26] The costs indicated in the table are all in UGX (Uganda Shillings). See preface for exchange rates.
[27] Some important data to note: *Petrol: 1L = UGX 3000; Diesel: 1L = UGX 2800.* The prices in the rural areas are increased because the vendors are not actual petrol stations, just those acting as middle men.

Once again, this is an indication that the typical economic (energy) activities are difficult to model in such cases.

Town	Equipment	Fuel Cost	Transportation Cost	Frequency[a]
Bigodi	Battery	3000	1500	1
Bishese	Battery	10000	4000	2
Ibanda	Petrol Gen	45000	6000	3
Kabujogera	Battery	8000	2000	2
Kahunge	Battery	12000	0	3
Kichwamba	Battery	5000	2000	2
Kihura	Battery	3500	2500	1
Kyakatara	Battery	3000	1200	1
Kyegegwa	Battery	8000	3000[b]	2
Kyenjonjo	Solar PV	0	0	0
Rwehamba	Diessel Gen.	10000	3000	1

[a] Frequency here is determined on a weekly basis

[b] Despite the fact that there is a battery charging station within a very short walking distance, the entrepreneur decided to have his battery charged elsewhere because he believes that the charging station has faulty equipment. A quote from him indicates:

> *"When I started taking my battery to the man here, everything seemed fine but after a few times, I realized that it would not last as long. It would die very fast and I asked him what could be the problem even though I used it for the same amount of time. His response was that it was my battery that was faulty but I suspected that he was not charging it fully, even though he charged me the full price. The battery was only about two months old so I did not think it was the problem. I took it to another place and my problem was solved and I realized that my suspicions of the man here was correct. It is unfortunate since I have to pay more for transportation but my battery now serves me longer."* – Kyegegwa General Store Entreprenuer

Table 3.10: Distribution of General Stores showing each town and the associated costs of accessing electricity. The figures in the tables are estimates given by the entrepreneurs, some have accurate numbers that they document, while others just gave an estimate off the top of their head.

Several factors lead to the high cost of access to electricity, which consequently leads to higher costs of goods and services offered by the micro-enterprises. On average, the cost of transporting the fuel is almost as high as 50% of the cost of fuel or charge due to a poor road network. Solutions that would reduce or completely eliminate the cost of transportation would improve on the prices of services offered, allowing the micro-enterprise to establish a profit elasticity while still meeting the needs of the poor, thus helping in eradicating extreme poverty, a key goal many organizations want to meet.

3.4.2 Income Generation and Profit Analysis

The inhumanity of poverty is becoming more known in the world day by day. As more concerned people become aware of its pervasiveness, more people of good will are calling for solutions to fight that poverty. Along with the rapid increase in number of poverty fighting programs, unfortunately, there have been many non-viable and incorrect assumptions (such as income elasticity) about how to eradicate poverty or what to do about it. Many people in power (directing poverty reduction programs) have agreed with those incorrect assumptions, and actions based on them may contribute to the continuation of poverty rather than its reduction [Worldbank, 2006].

In this study, we look at the income generated by the micro-enterprises, still focusing primarily on the general stores and cellphone charging stations, to assess the profit generated. As stated earlier, the cost analyzed is not the true cost but gives a rough idea of what the entrepreneurs 'take-home' profit is. The following tables show the micro-enterprises, the sales made, and profit on a weekly basis.

Town	**Total Sales**	**Total Cost**	**Profit**
Bigodi	56000	4500	51500
Bishese	42000	14000	28000
Ibanda	82000	51000	31000
Kabujogera	70000	10000	60000
Kahunge	45500	12000	33500
Kichwamba	22400	7000	15400
Kihura	47600	6000	41600
Kyakatara	29400	4200	25200
Kyegegwa	64400	11000	53400
Kyenjonjo	37800	0	37800
Rwehamba	38500	13000	25500

Table 3.11: Table showing income generation from sales of goods at general stores on a weekly basis.

Town	Charge Rate[a]	# of Customers[b]	Total Sales	Total Cost	Profit
Bigodi	1000	60	60000	0	60000
Bishese	1000	90	90000	33000	57000
Ibanda	500	120	60000	18000	42000
Kabujogera	600	60	36000	6000	30000
Kahunge	500	90	45000	13500	31500
Kichwamba	400	90	36000	6000	30000
Kihura	600	90	54000	6000	48000
Kyakatara	600	90	54000	8500	45500
Kyegegwa	500	120	60000	7000	53000
Kyenjonjo	700	120	84000	14000	70000
Rwehamba	500	72	36000	12000	24000

[a] Charge Rate is given in USHS/per full charge. The total sales, total cost and profit are also given in Uganda Shillings
[b] Number of customers are accounted for on a weekly basis

Table 3.12: Table showing income generation from sales of services at cellphone charging stations on a weekly basis.

From the data collected, we see that profits achieved would be higher if the costs were cut down by introducing appropriate technologies that would reduce on the cost of accessing electricity. Awareness becomes a key component in the provision of such technologies. While users have the right to access quality services, sufficient information must be provided and examples of the cost-effective mechanisms to convince them on what to purchase. Examples of working models also could provide a better understanding, especially because education is a key barrier as discussed later.

3.5 Impacts of Access to Electricity on the Micro-Enterprises

Production is the process of combining inputs to make outputs. While we do not focus on production in the context of manufacturing or the like, it is important to consider that a micro-enterprise is an organization, owned and operated by private individuals (entrepreneurs), that specializes in production. Essentially, an entrepreneur will have inputs, where they receive some kind of goods or tangible product that can be used to generate a service, sells its output to customers and receives revenue in return. Understanding the process from the inputs to attaining revenue gives a good perspective as to the impacts of access to electricity. Figure 3.12 shows what the ideal environment, operation and flow of the micro-enterprises should be, showing the access to electricity and its impacts.

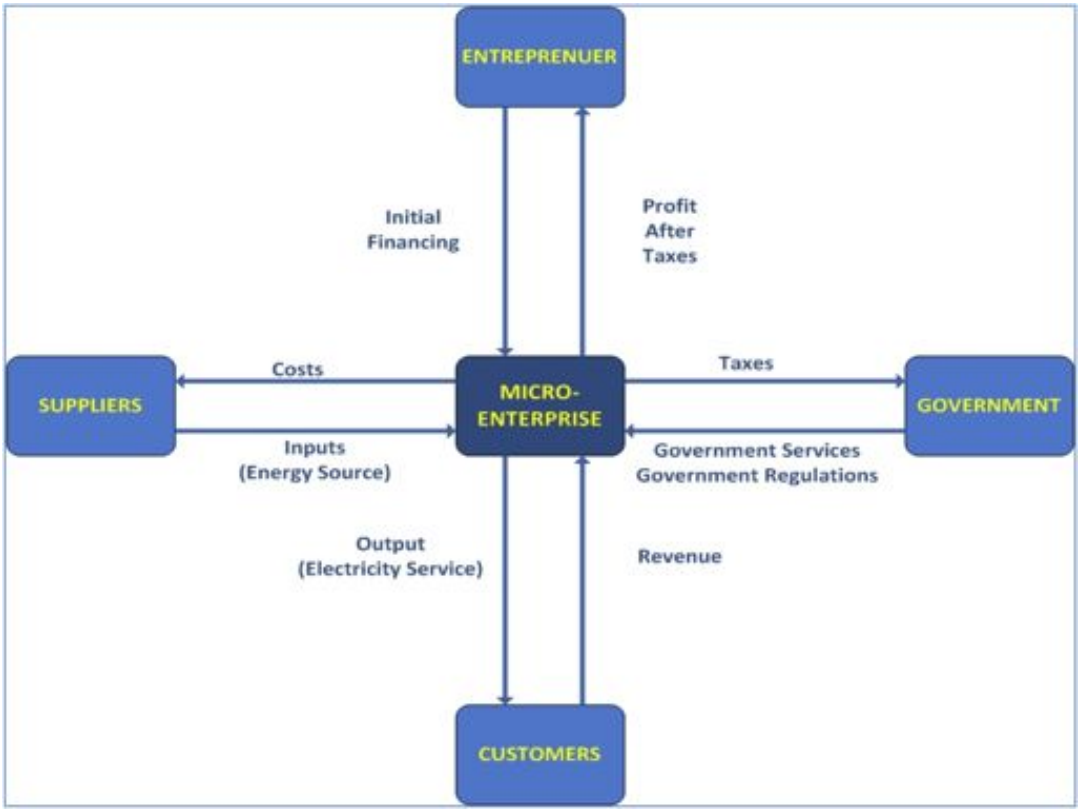

Figure 3.12: Ideal environment, operation and flow of the micro-enterprises should be showing the access to electricity and its impacts

As in most systems, ideal configurations hardly function as expected and this is the case with the micro-enterprises interviewed. Success of policies to assist development of the micro-enterprise sector will have to consider the actual performance of the business and how to resolve the areas that are not functioning ideally. Figure 3.13 shows what the actual performance of the micro-enterprises was.

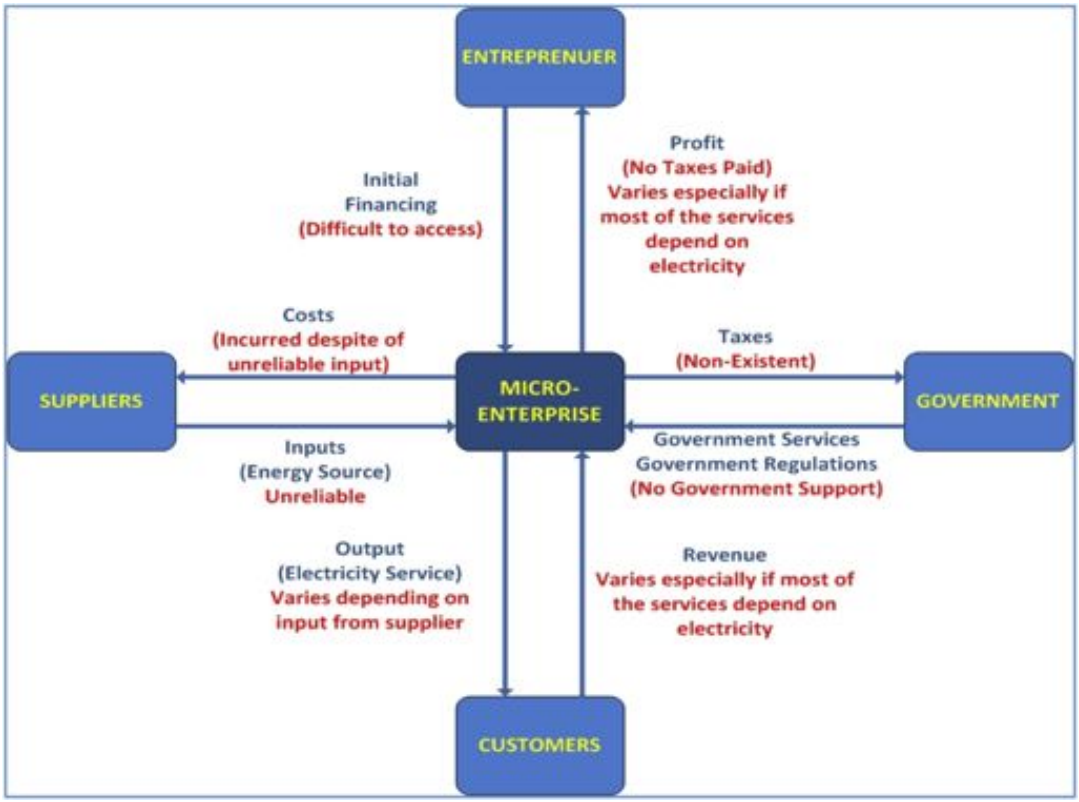

Figure 3.13: Actual environment, operation and flow of the micro-enterprises should be showing the access to electricity and its impacts

Diffusion theory [28] shows a pattern of diffusion starting with adoption of a new technology by so-called innovators, followed by a period of fast diffusion where the

[28]The diffusion theory, also known as the diffusion of innovations theory, is a theory concerning the spread of innovation, ideas, and technology through a culture or cultures. The theory has been extensively studied by sociologists, psychologists, and anthropologists. Diffusion theory states that there are many qualities in different people that cause them to accept or not to accept an innovation. There are also many qualities of innovations that can cause people to readily accept them or to resist them. According to diffusion theory, there are five stages to the process of adopting an innovation. The first stage is knowledge, in which an individual becomes aware of an innovation but has no information about it. Next is persuasion, in which the individual becomes actively interested in seeking knowledge about the innovation. In the third stage, decision, the individual weighs the advantages and disadvantages of the innovation and decides whether or not to adopt it.After the decision comes implementation, in which the individual actually does adopt and use the innovation. Confirmation is the final stage. After making adopting the innovation, the individual makes a final decision about whether or not to continue using it based on his own personal experience with it [Hall and Lieberman, 2006].

innovation catches on, and finally a period of low growth as the group of so- called laggards finally adopt the technology. In this study, we consider the diffusion theory to look at how many micro-enterprises recognize the impacts of access to electricity and the influence it has on their micro-enterprise. The overviews and specific examples in Chapter 3 indicate that adoption of electricity generating equipment and appliances is not 100%. Therefore, it appears that the diffusion process is still ongoing, or will not reach 100%. According to a diffusion perspective, once energy infrastructure is in place, it may be mainly a matter of time for the modern energy carriers and appliances to diffuse. For the analysis of impacts of electricity over time, it is necessary to have insight into the time span since the electricity supply became available. However, the fieldwork shows that it is not easy to demarcate the timing of introduction and also longer periods are needed to show full impacts on the micro-enterprise.

The following analysis will give an indication on the time dimension of the adoption process as it is taking place in the research area.[29]

Town	**Visit 1**	**Visit 2**	**Visit 3**	**Visit 4**	**Average**
Bigodi *	10	7	12	11	10
Bishese	15	15	20	10	15
Ibanda *	15	15	22	28	20
Kabujogera	10	5	15	10	10
Kahunge *	10	10	20	20	15
Kichwamba	15	15	15	15	15
Kihura	15	12	15	18	15
Kyakatara	15	15	15	15	15
Kyegegwa *	20	20	20	20	20
Kyenjonjo	10	20	22	28	20
Rwehamba	10	8	15	15	12

* The cellphone charging station interviewed in this town increased their capacity by purchasing an additional battery thus avoiding down times when they cannot get the battery charged in a day or less.

Table 3.13: Table showing approximate number of customers during each visit.

[29]The visits correspond to the following dates: Visit 1: May 2008; Visit 2: October-November 2008; Visit 3: April-June 2009; Visit 4: October-December 2009

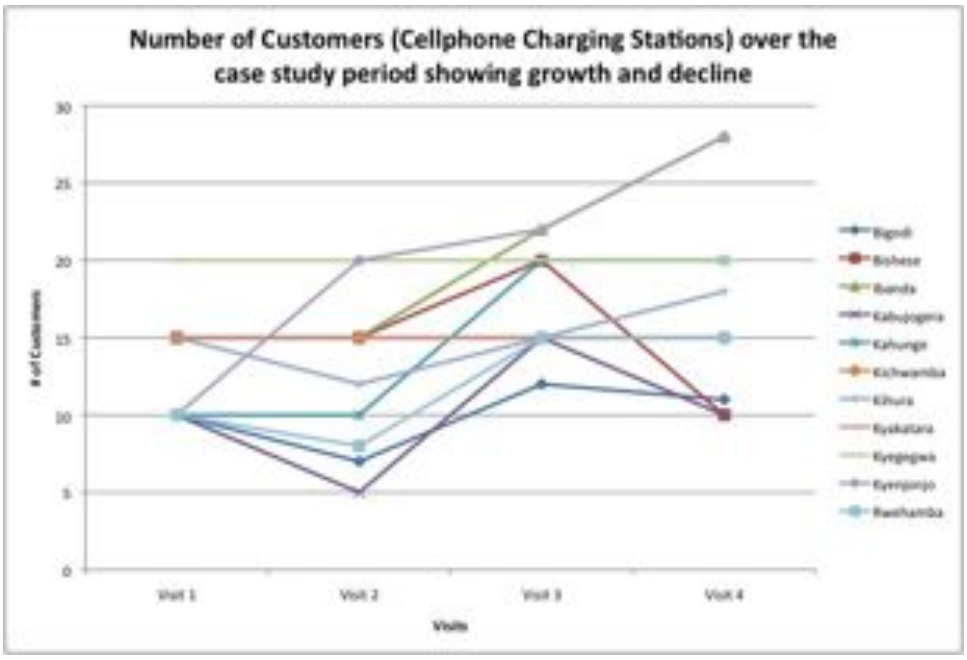

Figure 3.14: Daily number of customers for the Cellphone Charging Stations showing growth in those that increased their access to electricity

As shown in both table 3.13 and figure 3.14, there is a marginal increase in the number of customers for those that increased or improved their electricity access compared to those that did not. While the thought of an increase of 3 customers may not seem significant, it is important to note that the daily incomes are generally low and therefore an increase, as low as it may seem, turns out to be an important growth for the micro-enterprise.

CHAPTER IV

Barriers to Electricity Access

4.1 Introduction

There are about 1.6 billion people in developing countries without access to grid electricity and 2.5 billion people who are dependent on traditional biomass fuels for cooking and heating [IEA, 2002]. This severely limits their development possibilities and may negatively impact their health. Rural development is an integral part of national development policy in these countries. Building basic rural infrastructure and improving transportation and access to markets is vital. Decentralized energy systems can improve the availability, particularly to the poor, of reliable, affordable, economically viable, socially acceptable and environmentally sound energy.

There is no universally applicable prescription to the problem of access to off-grid electricity in rural areas. Lack of access to electricity and rural poverty are closely correlated. Not only is electricity a pre-requisite for ameliorating living standards, it is also an indispensable input for productive and economic activities. For rural populations, the positive impacts of electricity inputs for basic activities such as pumping water for drinking and irrigation; lighting for extending working and learning hours; and powering small-scale rural industry have considerably great socioeconomic benefits

Lack of access to information has been manifested by end users and decision-makers alike. In India, for example, knowledge about various renewable energy technologies has at times proved a considerable barrier in the implementation of off-grid electrification and energy technology programs [Chaurey et al, 2004]. Policy makers are not always aware about the costs and savings of alternative energy technologies while the micro-enterprise owners also have low awareness levels. [30] There is also lack of knowledge on appropriate policies that are required for the penetration of energy technologies. Thus, an important barrier to overcome when establishing alternative solutions in areas with available resources is the dissemination of information among decision/policy makers and final users of off-grid electricity.

This chapter characterizes the main barriers that have negative impacts on off-grid electricity access to low-income consumers in rural areas of western Uganda. Low consumption per unit significantly reduces the recovery period for initial investments. [31] This is aggravated in the case of rural markets by high dispersion, which requires higher initial investments. This situation has become more serious after the privatization process, which maximizes the value of assets to be sold and to minimize obligations to future concessionaires. Once private distribution companies are in place, weaknesses in the framework become evident. In particular there is a lack of incentives and obligations to implement off-grid electricity access ventures to improve and sustain access to electricity to low-income consumers. Also discussed are the difficulties related serving the low income and the typical domino-effect [32] it has on the community.

[30] Several entrepreneurs indicated that they were not aware of newer technologies that could cut down on their cost of accessing electricity.

[31] The recovery period is marked by rising sales and production, improved consumer confidence, and in many cases, rising interest rates. This is the period that would take for the investment to repay itself.

[32] Domino effect is a chain reaction that occurs when a small change causes a similar change nearby, which then will cause another similar change, and so on in linear sequence. The term is used as an analogy to a falling row of dominoes. It typically refers to a linked sequence of events where time between successive events is small.

4.2 Access to Capital and Financial Support

Global poverty exists today at a startling scale; while the exact numbers are debated, some estimate that four billion people worldwide live on less than two dollars a day [Prahalad, 2002]. According to Prahalad and Hart, profitable corporations should not ignore these traditionally overlooked people, collectively dubbed the "Bottom of the Pyramid" [33] because of their considerable combined purchasing power. Thus, if companies are innovative enough to create or tailor their products to the economic realities and life needs of these people, a significant profit can be won. At the same time, this groups entry into the market would hopefully better their quality of life and aid in regional economic development.

As a consequence of technological change, globalization and market integration in the micro-enterprise sector of the rural economy has become notably important. High poverty rates have resulted in increasing pressure to diversify production into value-adding, market-oriented products and the development of alternative sources of income. Capturing the benefit of globalization calls for a competitive, market oriented production and service. Profitability is further limited by lack of working capital and very basic entrepreneurial skills. This is partly explained by the fact that off-grid solutions in developing countries often have to involve small companies that are prepared to serve small rural markets; evidently, the lower the average firm size, the more easily it gets into financial difficulties and the less the likelihood of it having access to private funding at favorable terms.

The lack of financial capital has broad implications for micro-enterprise growth as well as the effectiveness of other input factors. Standard growth theories have explored the importance of input factors such as capital and labor in the production function of firms and countries. At the micro level empirical studies have estimated

[33] In economics, the bottom of the pyramid is the largest, but poorest socio-economic group. In global terms, this is the 4 billion people who live on less than $ 2 per day [Prahalad, 2002]. The phrase bottom of the pyramid is used in particular by people developing new models of doing business that deliberately target that demographic, often using new technology.

the impact of access to finance for capital constrained micro-enterprises [Suresh et al, 2008; Barnejee et al, 2009; Karlan et al, 2009]

Access to financial capital is a rather obvious input in business development. However, response from the interviews in this research shows is that it is not simply a matter of providing micro-credit to enterprises for rural development to take off, with the use of electric appliances. One aspect of this is that the objective of entrepreneurs in rural areas is not necessarily growth of enterprises, and that if investments were made, priorities would be in goods or in the building rather than in electric appliances [Sologuren, 2006]. Secondly, the cost of some of the equipment to operate on off-grid electricity (such as more advanced carpentry machines or grain mills for larger than village scale operation) is beyond the level of micro-credit. This implies that microcredit, the commonly promoted financial instrument to promote enterprise establishment and enterprise upgrading, is insufficient for the entrepreneurs who typically cannot access mainstream credit infrastructure to move beyond small scale appliances. A third limitation of formal credit infrastructures is that they often do not match the way rural entrepreneurs work (especially in informal enterprises), their attitudes to borrowing money and their motivations for running a business. Although micro-credit schemes are available, entrepreneurs prefer to draw on family sources such as loans from a relative as seen later in this chapter. In part, providing the right type of financing mechanisms means understanding gender issues. Rural small scale enterprises are often the domain of women who have different motivations and assets to men which influence their attitudes to and capacity for borrowing money. Understanding these aspects will ensure that micro-credit is targeted appropriately.

In Uganda, inequities cut across, gender, socio-economic and tribal groups and are reflected in the poor micro-enterprises using less energy than the wealthier ones, the latter having more choices and capacity to afford better electricity generating

equipment and appliances, which often translates in savings per unit of electricity consumed. From the data collected, we see that 62% of the fifty-six micro-enterprises purchased used electricity generating equipment compared to 38% who purchased them as new.

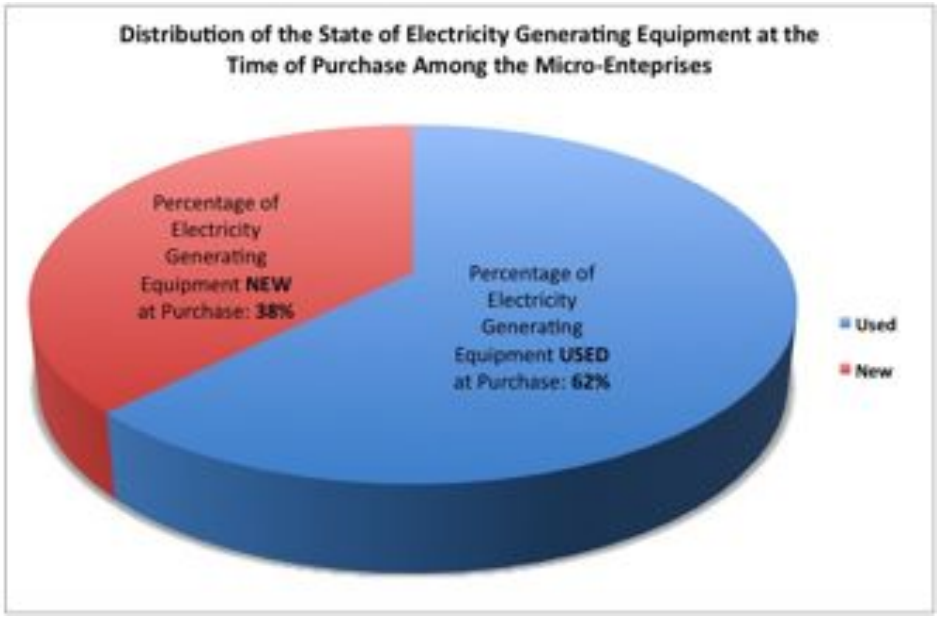

Figure 4.1: Distribution of the State of Electricity Generating Equipment at the Time of Purchase Among the Micro-Enterprises

While the private sector is a key player in financing energy for development, it is essential to remember that conventional private investors focusing on maximizing returns would hardly be attracted to the idea of providing access to electricity to the poor - unless subsidies or other financial incentives are in place and clear policies are set in advance. Therefore, besides the existing funding mechanisms, other innovative mechanisms are required which can attract different sources of capital targeted to meeting the needs of the poor and don't stress the economies of the area even further.

The funding mechanisms revealed through the interviews included the following:

- **Personal Savings:** Defined as income not used for current consumption. A serious problem confronting many developing countries is the savings gap, which essentially means that these countries find it difficult to finance investments needed for growth from domestic saving. Since saving depends on income, low levels of income that characterize developing countries translate into low levels of saving. Moreover, in developing countries, the majority of the people are poor and the distribution of income is skewed in favor of a small group of businessmen, workers in the government bureaucracies, and the elite whose consumption behavior tends to mimic the consumption behavior of their Western counterparts [Miracle, 1973]. Interviews from this research indicate that there are deleterious effects of low income on saving, therefore, there is difficultly in purchasing of equipment or appliances due to the lack of finances.

- **Loans from Family/Friends:** Person-to-person lending (social lending) is, in its broadest sense, the name given to a certain breed of financial transaction (primarily lending and borrowing, though other more complicated transactions can be facilitated) which occurs directly between individuals without the intermediation of a traditional financial institution. The "family and friend" model concentrates on borrowers and lenders who already know one another, as with two (or more) friends or business colleagues formalizing a personal loan. The family and friend model emphasizes collaboration, loan formalization and servicing. In Uganda, it is a common practice, especially due to the fact that most of the villages are comprised of a few big families and trust relationships strong with the fear of one being 'ex-communicated' [34] from the family.

[34] Ex-communication is a religious censure used to deprive or suspend membership in a religious community. The word literally means putting someone out of communion. We use the same definition in regards to someone being put out of the village.

- **Bank Loan:** Commercial banks in Uganda have shunned lending to micro-enterprises for a long time and there is limited expertise in the industry to make a good assessment when it comes to micro-enterprises. Issues like availability of market for the product or even the ability of the micro-enterprise to sustain quality production and meet orders after getting the loan are often difficult for the bank to assess. When faced with unanswered questions or given answers that cannot be verified, the bank will not give a loan. From the bank's point of view, any loan given is a business transaction which has fit into a tight system of evaluation before being disbursed. For a banker to make a valid assessment for a small business loan, it is necessary that he or she understands the micro-enterprise the same way the entrepreneur does. This is not easy and most micro-enterprises miss loans they deserve because bankers fail to understand their businesses. A small number of entrepreneurs in the case study have access to bank loans, primarily due to the lack of collateral and also inability to create a solid and promising business plan. [35]

- **Micro-Finance Institution Loan:** By definition, micro-finance means making very small loans to people who need business capital but can't qualify through banks. These loans are typically less than $500 and might be used to purchase a battery or a small generator. Micro-finance is not a long-term funding option for entrepreneurs and can be considered more as "lenders of last resort" - and it is not an alternative to private equity or 'angel money'. [36] Effective delivery of micro-financial services is challenging under any circumstance. Due to the fact that the loans are typically in such small amounts, collateral

[35] While banks may seem extremely difficult to obtain a loan for a micro-enterprise startup or development, a few banks have reviewed their processes and methods of allocating loans with goals of reaching the common man. Two banks that were interviewed were Equity Bank and Kenya Commercial Bank, both in Fort Portal. Both banks have special loans promoting micro-enterprises, especially women-owned businesses. This is following in the model established by Muhammad Yunus and the Grameen Bank in which they made efforts to create economic and social development from below, liberating those who could not receive any kind of loan. They show that lending to women had a 99% payback rate and society developed [Yunus, 2005].

[36] Angel money is funds provided by an affluent individual for a business start-up, usually in exchange for convertible debt or ownership equity.

is not much of a condition expected and most of the borrowers do not have collateral. Other factors that face the borrowers are such that they do not have formalized documents showing ownership of land, but the micro-financing institutions tend to work with them because of different relationships established in the community. The disadvantage of the micro-finance loans is that the interest is typically high, at times up to 40% and payback period is short, thus making the entrepreneur focus all the income on paying back the loan.

- **Donations:** While donations may be viewed from different perspectives, it is one of the strong supporting arms of most micro-enterprises. Obtaining a generator in Uganda may be anywhere from about $80, which in most cases is very expensive for entrepreneurs but not a costly gift from a tourist. Many entrepreneurs have attempted this as a strategy in obtaining equipment and appliances. In some aspects, it complicates things because it is hard to assign a value to an item given and unsure whether it was purchased new or used. A brief interview with the managing director of Umeme Limited [37], Uganda's electricity distribution company, shows the importance of small donations to the micro-enterprises:

  Q: *"In regards to short-term solutions for those in the rural areas, what do you think can be done in assisting them?"*

  A: *"The only thing that is suitable for such a case is individual investment on the small-scale electricity generation. A solar panel installed at a small business can create great impact and generate more income for the owner. They have to attempt to acquire capital from banks or micro-*

[37] Umeme is Uganda's grid-electricity distribution company under the regulation of the Electricity Regulation Authority (ERA). Currently, there are approximately 2M customers through out the country with infrastructure installed through most of the main cities in Uganda. In 2009 Umeme has invested approximately USD 30M in expanding the infrastructure through out the country. Umeme is wholly owned by the Commonwealth Development Corporation (CDC) of the United Kingdom. CDC is a UK government-owned company, based in the United Kingdom, with investment assets mainly in the emerging markets of Africa, Asia, Latin America. It has an asset base of USD 4B of which approximately 8% is currently in the energy sector. Umeme is its first investment in the distribution end of the power sector but is actively pursuing acquisitions seeking to increase its investments in the emerging markets.

financing companies. Individual donors at small amounts can also contribute in making this a success. For example, one giving USD100 to a small business owner can assist in the purchase of a 30W solar panel, battery and installation costs. That is roughly USH 200,000. That goes a long way for them. I dont encourage the giving of money, because its not always used in the right ways; I encourage one to go and purchase the equipment for the business owner, thus once knows it was put into good use. I also encourage that full amounts are not given. Have the person pay a portion of it. It gives them a sense of ownership. Utility companies are more interested in the long-term benefits so we dont play a role as much for the short-term solutions. The solutions that you are seeing taking place now are those that were planned years ago."

In areas where there is grid electricity, current costs for people to access electricity are pretty high. One has to pay approximately USH 450,000 (USD 225) if there is no pole close to the micro-enterprise, and USH USD 150,000 (USD 75) if there is a pole close by, so one only pay for pulling the line. With such costs, most people without a pole find it hard to get access. The areas covered in this study are not in close proximity to the grid, but important to note that even if they were, it would be difficult for most to have access to electricity due to such high costs. Therefore, funding mechanisms play a major role in decision making on the equipment that will be purchased. Figure 4.2 shows the distribution of funding mechanisms among the micro-enterprises interviewed.

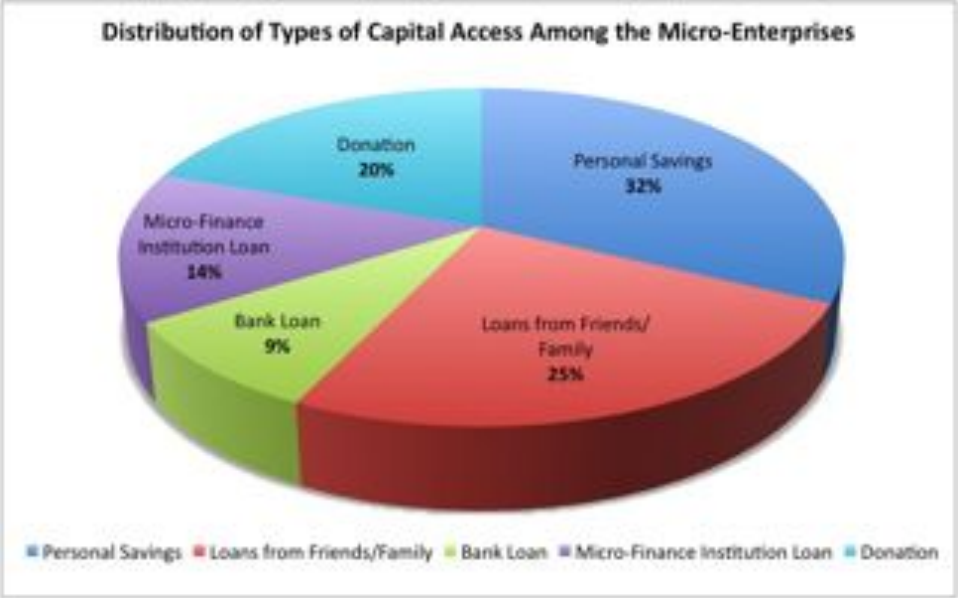

Figure 4.2: Distribution of Funding Mechanisms Among the Micro-Enterprises

To further understand the issue of capital, we looked at both the Cellphone Charging Stations and General Store. The important factors to consider are the purchase status, initial investment and maintenance. Over 60% did not do a regular maintenance on the equipment, and applied a theory of waiting till it is broken before taking it in. The problem with this is that there turns out to be a long wait period during which they would loose customers. Tables 4.1 and 4.2 show the distribution of the funding mechanisms through the different towns.

Town	Equipment	Purchase Status	Initial Investment	Maintenance[a]
Bigodi	Solar PV	New	Donation	No
Bishese	Diesel Gen.	Used	Personal Savings	No
Ibanda	Battery	Used	Personal Savings	Yes
Kabujogera	Battery	Used	Donation	No
Kahunge	Battery	New	Donation	Yes
Kichwamba	Battery	Used	Personal Savings	Yes
Kihura	Battery	Used	Personal Savings	No
Kyakatara	Battery	New	Loans from Family/Friends	No
Kyegegwa	Battery	New	Micro-Finance Loan	No
Kyenjonjo	Battery	Used	Donation	Yes
Rwehamba	Battery	Used	Personal Savings	No

[a] Maintenance here refers to regular servicing of the equipment rather than just the typical repairs once there's a problem.

Table 4.1: Distribution of Cellphone Charging Stations showing each town, state of equipment at purchase, the funding mechanisms and if regular maintenance is conducted or not

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Town	Equipment	Purchase Status	Initial Investment	Maintenance[a]
Bigodi	Battery	Used	Personal Savings	No
Bishese	Battery	New	Loans from Family/Friends	No
Ibanda	Petrol Gen	Used	Loans from Family/Friends	Yes
Kabujogera	Battery	Used	Personal Savings	No
Kahunge	Battery	New	Donation	Yes
Kichwamba	Battery	Used	Loans from Family/Friends	No
Kihura	Battery	Used	Personal Savings	No
Kyakatara	Battery	Used	Donation	No
Kyegegwa	Battery	Used	Loans from Family/Friends	Yes
Kyenjonjo	Solar PV	Used	Donation	No
Rwehamba	Diesel Gen.	Used	Personal Savings	No

[a] Maintenance here refers to regular servicing of the equipment rather than just the typical repairs once there's a problem.

Table 4.2: Distribution of General Stores showing each town, state of equipment at purchase, the funding mechanisms and if regular maintenance is conducted or not

Literature and field experience shows that the poor require small amounts of energy to meet their basic energy needs. While this is clear, access to capital forms a great barrier to accessing electricity for many and needs to be addressed. Worldwide, economic barriers to electricity access include high initial costs and small-scale production of equipment to meet the needs of low consumers. Moreover, responding to the entrepreneurs' capacity and willingness to pay [38] is essential. High costs of access to off-grid electricity otherwise serve as an excuse not to provide the electricity-dependent services. In fact, the capacity and willingness to pay of the entrepreneur may surprise lending institutions, especially once communities are more educated on the advantages of using electricity and it's services. While addressing capital, understanding capacity and the willingness to pay of the entrepreneurs will help policy makes and investors in gauging consumption subsidies and the like.

The local financial sector is weak overall, and the banks and other financial intermediaries have no experience with project financing in electrification. The pay-back period on previous investments corresponded to the two to three years maturity of the loans [UBS, 2008]. To finance off-grid electricity access projects with long pay-back periods, where revenue depends on uncertain demand forecasts about the ability of the entrepreneurs to access electricity in sufficient quantities and at cost-coverage prices will be considered as a high risk lending activity. Once confidence has been gained over the years from the successful implementation of electrification projects, this barrier will be reduced. Initially, there may be need to facilitate financing to project sponsors.

[38] Willingness-To-Pay (WTP) is the maximum amount a person would be willing to pay, sacrifice or exchange for a good or service.

4.3 Adoption: Equipment and Appliances

The adoption and usage of electricity generating equipment and appliances can change micro-enterprise processes, and the way people live and work. The technology adoption lifecycle method describes the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of defined adopter groups [Rogers, 1962].

Figure 4.3: A graph of Everett Rogers Technology Adoption Lifecycle model [Rogers, 1962]

While this research does not necessarily consider new products, I probe the entrepreneurs to understand how they adopt different technologies in electricity generation as well as appliances. Lack of access to information has been manifested by the entrepreneurs showing indications of a lack of understanding on the benefits of newer technologies and the savings in expenses for electricity generation. Since a high percentage of the micro-enterprises purchase used equipment and appliances (see figure 4.1), inappropriate technology choices were evident through the case study. There is poor effort in selecting technologies that will best fit the need of the micro-enterprise, and the training and ability to understand the maintenance needs lacks thereof. Table 4.3 shows the distribution of the micro-enterprises based on two main categories that assist in the decision making of the purchase.

Decision Making Influence[a]	Number of Micro-Enterprises
Purchase After Research Done	18
Purchase Based on Recommendation	38

[a] While this is the information collected during the interviews, in is unclear if all the entrepreneurs were aware as to how they came around to a decision in purchasing.It is difficult to completely distinguish if the understanding of researching a product prior to purchasing was done. As noted earlier, this is a preliminary study and more data would need to be collected for verification.

Table 4.3: Distribution of micro-enterprises based on the decision making for purchase

An issue of trust became evident in discussions with the entrepreneurs. It was clear that many would prefer to purchase an item that someone else recommends rather than actually investigating what the need is and how the equipment or appliance will fit the needs of the micro-enterprise. There is a strong push by the sales people to develop trust in a community and sell the technologies to the locals. Some of the sales people also have collaborations with local micro-financing institutions to help the entrepreneurs purchase expensive equipment. The following quotes from some of the entrepreneurs show how adoption of technology is slow and does not necessarily follow the model described by Rogers in this case.

To address the barriers relating to inappropriate technologies, several financing institutions could ensure that they can assist the entrepreneurs in selecting the right product to meet the needs. A critical influence will also have to come from those selling the products to assist the buyers on what they actually need. A final, and yet very important intervention has to come from the education of the entrepreneur, another barrier to electricity access as discussed in section 4.5.

4.4 Infrastructure and Weather Constraints

Uganda lags well behind many other developing regions in access to infrastructure services [UN, 2008]. Limited gains made in the 1990s continued in the early 2000s, and there is now clear evidence that many countries are failing to expand services fast enough to keep up with rapid demographic growth and even faster urbanization [Banerjee, 2008] If present trends prevail, Uganda is likely to fall even further behind other developing regions, delaying much needed development.

Access to infrastructure services [39] is limited in Uganda. Access to improved roads is impaired with lack of proper development planning and distribution of funds to reach the very poor. From tables 3.9 and 3.10, information on the cellphone charging stations and general stores, we see that over 50% of the costs of accessing electricity are spent on transportation. Typically, the distance will be approximately 6-10km of total travel, of which some times they have to walk or ride a bicycle to get the battery to the charging station or purchase fuel for example.

Driving in Uganda is a wonderful experience full of stunning landscapes and often quiet roads that can really be enjoyed. As long as you are properly prepared and have taken the time to learn the local road rules [40] Driving on 'murram' [41] roads is challenging and requires additional skills when compared to sealed or 'tarmac' roads. While a certain trip, say 10 km would average a few minutes, depending on the state of the road, such a trip could even last as long as 45 minutes because of the need to drive at very slow speeds and avoiding potholes. For such reasons, the

[39] In this research, I only consider the term infrastructure to be defined as the road system and how it affects transportation, one of the key components in electricity access for most of the micro-enterprises.

[40] While we would expect typical road rules to be those that accommodate for the all drivers, the experience proves to be different and understand signals even makes one appreciate traffic laws in developed nations. A good example, learned from experience, is the turning on your indicator while another car is approaching you, this enables them to gauge how far you are on your side, typically because there are not demarkations on the road

[41] In Africa and parts of Asia, laterite soils are used to build dirt roads. However laterite, called murram in East Africa, varies considerably in the proportion of stones (which are usually very small) to earth and sand. It ranges from a hard gravel to a softer earth embedded with small stones. Not all laterite and murram roads are therefore strictly gravel roads. Laterite and murram which contains a significant proportion of clay becomes very slippery when wet, and in the rainy season, it may be difficult even for four-wheel drive vehicles to avoid slipping off very cambered roads into the drainage ditches at the side of the road. As it dries out, such laterite can become very hard, like sun-dried bricks.

cost of transporting something from one town to another is usually high and most of the entrepreneurs indicate that when they need to purchase fuel for example, they would rather do it at a time when they need to purchase something else from the other town. This leads to a situation where they may go a day or two without accessing electricity. Figure 4.4 is an example of what typical transportation in the area is. While this may seem extreme, such a road is considered as one of the best and commonly used.

Figure 4.4: An example of good transportation and what would be referred to as a very good road

While we can see that infrastructure can be a barrier to electricity access, weather goes hand-in-hand as a barrier as well. Situated on the equator, Uganda enjoys a pleasant and warm climate throughout the year, with plenty of sunshine. Conditions can vary however, owing to the high altitude of some regions. For example, the Rwenzori Mountain range - at an altitude of 3,000 m, which is part of the area we studied, can expect rain throughout the year and evenings can be chilly. The hottest months are between December and February, with an average daily temperature in Western Uganda of 29 °C. Western Uganda receives approximately 1,500 mm of rainfall a year and there are two distinct rainy seasons: April - June and October

- December. Rain can fall anytime throughout the year as a result of three factors - high altitude, the influence of Lake Victoria, and the moist south-westerly winds that brings rains from the Congo. It does mean that the surrounding countryside is beautifully green and lush. Figure 4.5 is a representation of my travel through one of the regions where it had rained, and despite the car being a 4WD, we had to push it to get out of the mud. Such cases are very typical in Uganda.

Figure 4.5: An example of a situation due to a combination of poor infrastructure and inclement weather

Though this study does not focus on the infrastructure and weather patterns of Uganda, it is important to highlight how they affect access to electricity for the micro-enterprises. Policy makers should consider the development of such small business structures, and especially in places where Agriculture is the strongest economic driver, providing good roads can potentially lead to increase in income for those living under the poverty line.

4.5 Education

Improving access to electricity services is a growing concern for governments in developing countries, as well as for bilateral donor agencies, international organizations, and the multilateral development banks. An important part of this mission is expanding access to electricity services for an estimated two billion people who still lack such services [World Bank 1996, ESMAP 2000c]. Expanded access to electricity services is inexorably linked to today's transforming of the economic sector. Although ongoing reforms are showing success and being replicated, there is growing concern about their social and environmental sustainability. One of the key factors that may lead to this problems is the lack of education for those two billion people.

> THE 2002 WORLD SUMMIT ON SUSTAINABLE DEvELOPMENT CALLED ON WORLD LEADERS TO: ***"Take joint actions and improve efforts to work together at all levels to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the Millennium Development Goals, including the goal of halving the proportion of people in poverty by 2015, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty."*** [42]

Many barriers hamper service providers ability to provide electricity to the rural poor. Figure 4.6, inspired by the United Nations and the United States Agency for International Development, shows energy (and in our case we view it directly as electricity) as the center piece, or the missing link in achieving those development goals.

[42] World Summit on Sustainable Development. 2002. "Plan of Implementation of the World Summit on Sustainable Development." New York: United Nations, p. 5.

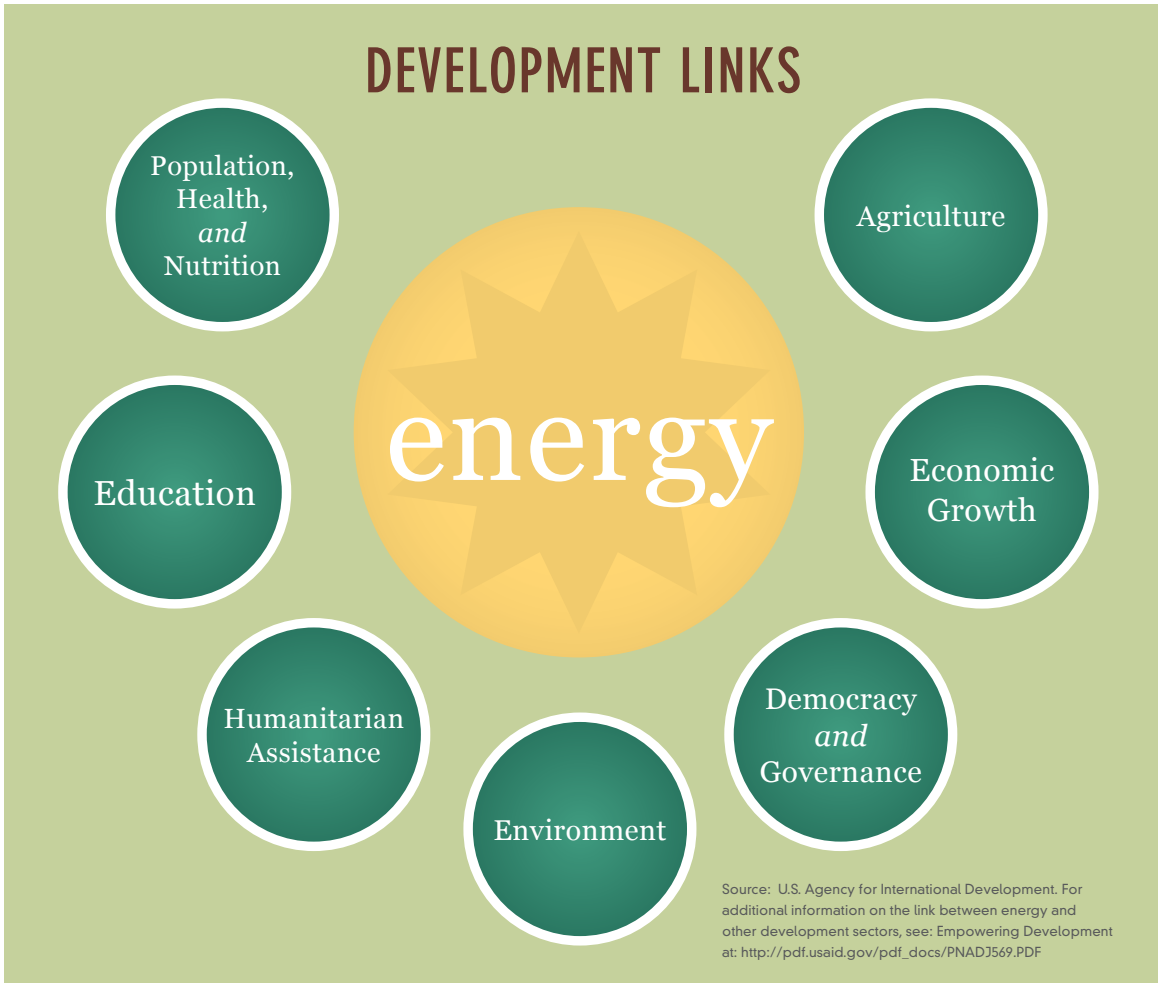

Figure 4.6: Link between energy and other development sections

Because education is an important part of it, during the interviews, I asked the entrepreneurs as to their level of education. The response show signs of what can turn out to be a vicious cycle because lack of electricity in schools (and consequently at home) leads to an undesired level of education that cannot compete with other enterprenuers at the same level. In today's society, where computing is becoming necessary to achieve productivity, most of the students would not have access to such exposure and at the point where they may intend on having their own micro-enterprise, they find it difficult to make educated decisions. Table 4.4 shows the responses from the entrepreneurs.

Level of Education Attained[a]	English Fluency [b]	Number of Entrepreneurs
Never Attended School	1	7
Attended Primary School - Graduated	3	15
Attended Primary School - Never Graduated	2	22
Attended Secondary School - Graduated	4	4
Attended Secondary School - Never Graduated	3	8

[a] Primary School is from P1-P7 (analogous to 1st - 7th grade here in the U.S.). Secondary School is from S1-S6 (analogous to 8th - 12th grade here in the U.S. Uganda still operates under the British 'O' (Ordinary) and 'A' (Advanced) level system and typically, not everyone goes to S5-S6 as it is considered somewhat optional. At completion of S4 they do receive a high school diploma)

[b] This measurement is an approximation based on how they responded to my questions. English fluency level is divided into the following categories: 1 - Poor; 2 - Average; 3 - Above Average; 4 - Native. The measurement is not very accurate due to factors like some being shy and afraid that their english is not good enough. It's a rough idea of where most of them would be rated (Uganda was a British Protectorate and therefore English is spoken by many)

Table 4.4: Level of education attained by the entrepreneurs and the english spoken.

It is commonly assumed that education has an important positive effect on economic growth, but to date the evidence for this assumption has been surprisingly weak. Evidence shows that, at the individual level, more years of schooling lead to higher income [Lutz, 2007]. Even then, empirical evidence relating changes in education measures to economic growth has so far been ambiguous. From the data obtained, only 7% of the entrepreneurs graduated from high school. Better education leads not only to higher individual income but is also a necessary (although not always sufficient) precondition for long-term economic growth. To make sound decision on what kind of equipment and appliances to purchase, sound education plays a key role and a lack of it is an indication as to why most may not understand the benefits of certain systems.

Investment in secondary education provides a clear boost to economic development, much more than can be achieved by universal primary education alone. Hence, the current focus of the United Nations Millennium Development Goals on universal primary education is important but insufficient. Universal primary education must be complemented with the goal of giving broad segments of the population at least a completed junior secondary education. While the role of this study is not to assess the level of education, we realize that it hampers the development of the micro-enterprises and measure need to be taken in ensuring that despite the level of

education, some amount of training is given in methods of electricity access in the rural areas. Enabling an entrepreneur to understand that despite a high initial cost of a Solar PV system, the reduction in costs is high and potential increase in income, reaching a goal of alleviating poverty.

CHAPTER V

Feasible Solutions and Recommendations

5.1 Studies Across the Globe

While this is a preliminary study, with further investigations needed, providing solutions that are feasible across the globe is essential the goal of projects as such. While we study very rural areas, an important aspect to mention is the migration towards urban areas. In 2005, 3.1 billion people lived in urban areas, nearly half of the world's population. By 2025, a projected 4.5 billion peoplenearly two- thirds of the worlds populationare expected to live in urban areas [UN ESA, 2006][43].

As urbanization rates steadily increase, governments are realizing that providing modern infrastructure services, especially electricity, is a high priority. Without electricity, much of this urban population will not be able to keep pace with the changing world and will lack opportunities to increase their skills and education, which will limit their employment opportunities. By taking the perspective of the entrepreneurs in the micro-enterprises in rural areas, small sustainable scalable solutions can be uncovered. The understanding of such solutions, the factors and mechanisms involved, leads to recommendation for policy development in the field of energy, as well as a support for business initiatives, to increase the impacts of electricity on income generation by the poor. In Section 5.2 I discuss two potential solutions in eradicating extreme poverty.

[43]United Nations. 2006. 'World Population Prospects: The 2006 Revision Population Database.' Accessed from http://esa.un.org/unpp/

5.2 Sustainable Scalable Solutions

Electricity access in itself is not a panacea to rural poverty issues. A successful intervention has the potential to stimulate development by modernizing existing needs and introducing new services. However the long term success of any project requires social sustainability to play a central role which can only be achieved by starting from the context of the users rather than the technology. Technology in itself is not the cure-all to rural development issues. In fact, installation of the same technology within different contexts can often yield contrasting results. There is no best-fit solution to energy needs, and carriers must be weighed carefully against the local situation, capabilities and preferences.

5.2.1 Case 1: Independent Power Producer Nexus

Different sizes of micro-enterprises can benefit from sustainable, efficient electricity services. While access to capital seems to be a barrier, there are several locals who are well-off and can afford to promote different ways of accessing electricity. In a case examined by a wealthy business owner in Kyenjonjo, I learned of several methods used to help other business owners access electricity in order to offer services. The owner has several businesses that provide the following services: cellphone charging, automotive battery charging, hair salon, video hall, electrical repair services and other services that may be needed such as dvd and cd duplication. The electricity generating equipment that he has is: 1 small solar PV, 1 Petrol Generator, 2 Diesel Generators and several car batteries. Depending on the service needed, he turns on the appropriate generator. The PV and batteries are primarily used for lighting and cellphone charging. The rest of the services are dependent on the customers that come in and when enough, then he can run the generator and typically will try to have more than one service at the time. Figure 5.1 is an example of a schematic diagram showing the flow of usage among the different ventures.

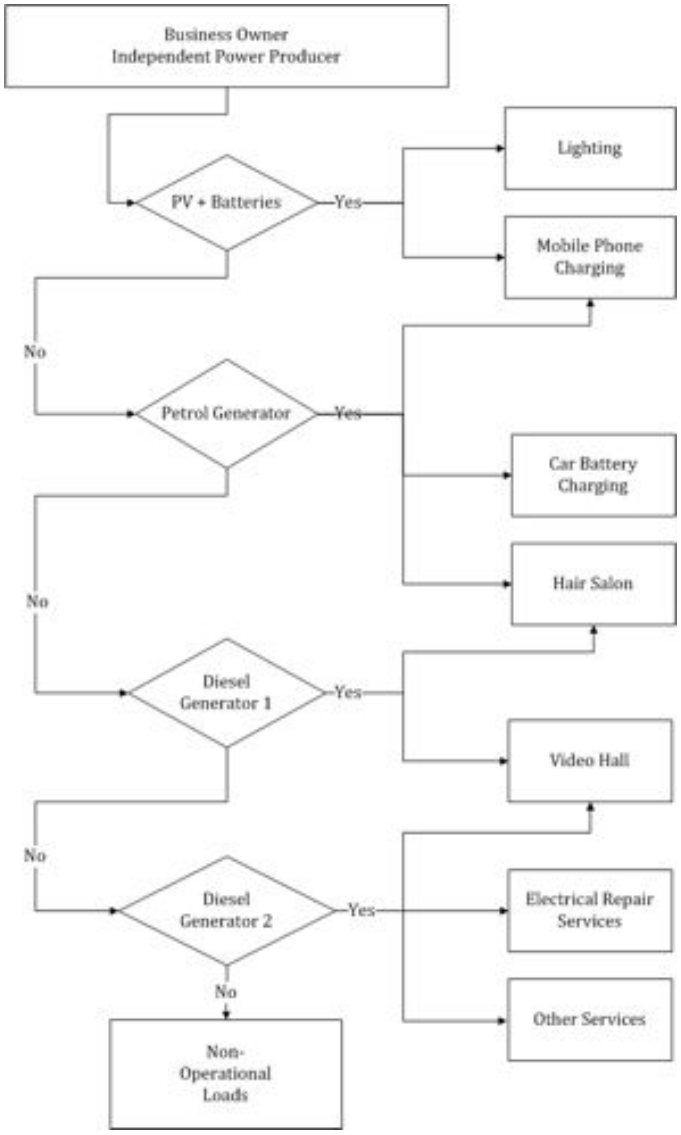

Figure 5.1: A schematic diagram showing the flow of usage among the different ventures based on the need at the time. [Special thanks to Abigail Mechtenberg for working with me on this model and a more detailed model is listed in Appendix D.2

While such a solution is functional (he does not run every single one of the businesses, just collects a percentage from each at the end of the day and small fee for overhead), it is important to note that one needs capital in order to achieve such a goal. Here the entrepreneur is able to purchase both the electricity generating equipment and the different appliances that provide the services. This could be a model that could be used in other areas where there is someone able to access capital.

5.2.2 Case 2: The Bicycle Generator, Improving Access in Kenya

In many developing countries, human energy is most commonly used to propel bicycles, but can also be used to generate electricity and power hand-crank tools. Human (mechanical) energy is converted into electrical current by means of a Direct Current (DC) generator that is connected by a fan belt to a bicycle flywheel. The electricity created by the DC generator can be stored in various types of lead-acid batteries. Tests at Oxford University showed that 75 watts of power is possible to be generated by an average rider at road speed in a one hour time frame. Wilson also found that at 18 mph it is possible to achieve 200 watts for short periods, while 750 watts is possible only for a second or so, under extreme load [McCullagh, 1977]. These calculations show that human/mechanical energy, if harnessed could add to existing battery banks, or could be set up alone to run appliances. Appliances that could be powered include radios, televisions, lights, power tools and other appliances that pull relatively low amounts of energy for their usage.

As an attempt to see the importance of such electricity generating devices in the most rural areas, I worked with technicians at MPALA Research Centre [44] in building a bicycle generator that would assist the employees at the center to charge the batteries they use in their homes. While not possible to show the residences of the villagers, figures 5.2 and 5.3 show the outside and inside of a 'banda' [45] which are very similar to those of the employees. The Mpala Wildlife Foundation [46] has

[44] Mpala is located on the Laikipia Plateau in north central Kenya, just north of the equator, northwest of Mt. Kenya and at an elevation between 1700-2000M above sea level. Mpala covers 49,107 acres of savannah and dry woodland habitats and is bordered by the Ewaso Ngiro and the Ewaso Narok rivers. There are vast expanses of low lying plains, covered with thorny scrub where unique rocky kopjes (a small usually rocky hill especially on the African veld) majestically rise above the skyline. Fifteen dams have been constructed on Mpala, and there are more that 250KM of internal roads.

[45] A hut-like accommodation, typically common in camp sites because they usually have amenities needed by most people

[46] The Mpala properties in Laikipia, Kenya were purchased by Sam Small in 1952 and bequeathed to his brother George in 1969. George Small focused his energies and resources on conserving the habitats and wildlife of Mpala and providing healthy livelihoods for Mpalas employees and families. In 1989 George created the Mpala Wildlife Foundation and the Mpala Research Trust to fund the activities necessary to achieve his vision. In accordance with George Small's mission, the Foundation supports the wildlife conservancy, a primary school for employees children, a community outreach program which includes the Mpala Mobile Clinic, as well as a working cattle ranch that successfully coexists with an abundance of wildlife. The Foundation contributes to the Mpala Research Trust that supports and directs the Mpala Research Centre, a well respected, international research facility located on the Mpala property.

made it a priority to make sure that all it's employees live in good conditions and that their children are educated.

Figure 5.2: Outside of a Banda [Photo: Courtesy of MWF]

Figure 5.3: Outside of a Banda [Photo: Courtesy of MWF]

To understand the need for such devices, the location to the closest grid connection is an important factor to consider. Mpala is located about 75KM from Nanyuki town, the closest to grid electricity. While they have funds that help to run a 30KVA diesel generator, a 22KVA petrol generator and several solar panel installed on the different buildings, those that suffer tremendously are the employees living at the MPALA village. They rely on batteries which have to be brought to the charging station, where the priority is charging batteries for the researchers. Thus finding a solution to meet the needs of the employees is likely to have a profound effect on success and efficiency during the work hours. Figure 5.4 show the initial stages of building the bicycle generator while figure 5.5 shows the final product charging a battery.

Initially, the bicycle generator did not show much interest among the villagers but after a site visit by the Board Directors, and the realization that one doesn't have to put too much into getting a full charge, it has become a popular electricity generating device. The locals rely on it more than they do at the charging station as they can go almost a week or two without a chance of getting their battery charged. Such small solutions have created interest in building a gym that will be generating electricity as people exercise, which is a facility lacking at the site.

Figure 5.4: Initial stages of building the bicycle generator

Figure 5.5: Final product charging a battery

The experience from Mpala, which continues to show success is an indication that as the villagers earn more income, they can potentially purchase such a device and find a way of creating more income by providing services that depend on electricity. Despite the fact that this example shows an improvement in the lives of the villagers, much more work is needed overall to dramatically address this issue through out the developing world by finding small simple solutions that can easily be applied.

5.3 Role of Local Governance

Local governments have a natural advantage in knowing and understanding the needs and resources of their own territories and so they can provide better local public goods to meet the demands of their populations. However, while the debate on governance has focused on the institutions of the national state less attention has been given to sub-national governments. While decentralization reforms cross the developing world have advanced, their implementation continue to face critical challenges. The budgets are limited or have grown beyond their competencies and opportunities for sustainable economic development have not accompanied new political accountability at the local level.

One important way that the local government can contribute in the role of electricity in economic development is by providing resources and material on different and appropriate technologies that can be used for different services. While most people may not trust a new salesman in town, it is more likely that they can find confidence in them if they had information from the local government. Typically, the experience sought in Uganda did show that prior to approaching the communities, one had to in-fact have discussions with the local chief on what the intentions of the study were. Dissemination of information would therefore be prevalent through the use of the chief's office. Methods in which the local government can achieve the results are:

1. Improve understanding of the importance and role of local governments for community development and the use of electricity for alleviating poverty through income generation
2. Disseminate and compare lessons learned, best practices, and tools generated from working with technicians, researchers, sales people and financing institutions.

3. Facilitate the exchange and comparison of experiences and approaches among practitioners from a cross-regional perspective

The challenge for developing countries, given their situation of extremely low incomes, is that of how to encourage the poor to participate in programs provided by the local government. Most poor populations are quick to agitate for participation but when it reaches the level of participating in the financing they still want some donor or central government to foot the whole bill. Central government on its part gets money from taxes paid by the people. But however efficient and effective a tax system is (which in Uganda it is not), if it is taxing a poor population, it will yield poor revenues.

There is a limit beyond which a hungry person can not milk a hungry cow. The fundamental problem with most African societies is that they suffer from double weakness. The local governments are weak while at the same time the private and civil society sectors are also weak. This double weakness is not only in terms of resources, human, material and financial, it is also in terms of institutions, systems, information, networking and many more. Their financial difficulties stem from this fundamental double weakness. Such weaknesses are the reason why the local governance find it difficult in implementing policies to assist the people with solutions and the benefits of using electricity for alleviating poverty.

5.4 Donors: A Sustainable Solution?

In developing countries the challenge of increasing electricity access in a sustainable manner is a problem of balancing the need to set prices to cover cost while keeping them low enough for the poor majority to afford. These are not easy objectives to achieve because they are inherently contradictory where the achievement of one objective is often at the expense of the other. Provision of modern energy service is crucial to the overall social and economic development and as such it forms a platform without which the MDGs cannot be attained. Lack of access to electricity in itself remains the clearest indicator of Energy Poverty and, indeed, of poverty in general. It is, therefore important that that donors can assess the methods of giving to implement the enhancement rural electricity access.

The energy needs of the poor are small, but small amounts of energy can make a significant difference to their lives. However, the great majority of people without adequate access to electricity live on less than US $2 per day, making it difficult for them to access good services, including access to modern energy services. Electricity access is not without cost and the initial expenditure on connections or better technologies can be high. There is a large funding gap in providing electricity access for the poor which has not been seriously addressed by existing financial mechanisms and financing institutions. An estimated US $435 billion would be required to provide electricity to all of the population presently unserved. Compared to current energy sector spending, the cost of delivering energy to meet the needs of poor people is only about 2.85% of total global energy investment [Worldbank, 2009]. This has to be funded by international aid, multilateral financing, climate change financial mechanisms, governments and local private sector investment.

While the private sector will definitely be one of the key players in financing electricity for development, it is essential to remember that private investors aiming to maximize returns would not be attracted by the idea of providing electricity

access to the poor unless subsidies or other financial incentives are in place and unless clear policies on tariffs and risks are set in advance. Over the past 30 years the international community has continually failed to make headway to reduce the number of energy poor. The approach has either not focused on actually delivering the needs of the poor, so the benefits have gone to wealthier groups, or has been unsustainable and driven by short term donor requirements.

> ***"Receiving assistance from my American friend has been very helpful for my business. Initially, they bought be a battery and a small inverter and then told me that I would have to buy my own clippers to cut hair. It was great but I still did not have enough money to buy everything I needed. I then realized that it would be a disappointment when they return to Uganda and see that I have not made any progress in opening up a barbershop. I borrowed some money from my uncle and bought one set. When they returned, they were happy to see that I have taken the initiative and they helped me to install lights and purchase a second battery. Now with the little money I make, I have been able to buy more clippers and hire someone else to help me because we get a lot of customers in the evening!"***

It is therefore clear that depending on donors for the improvement of electricity access will not serve as a viable sustainable solution but could be used for short term goals such as providing batteries to the micro-enterprises, but also teaching them on the usage and maintenance. Donations will have to go hand-in-hand with education, lest the gift becomes worthless if the user does not know how to maintain it.

CHAPTER VI

Conclusion

6.1 Main Findings

The main purpose of this thesis is to build understanding on how and under which circumstances rural entrepreneurs access electricity in off-grid locations and the influence that has on micro-enterprises. Although the topic of energy and poverty reduction is relevant from a policy perspective, empirical evidence needed to understand the mechanisms through which electricity can contribute to the economic development of micro-enterprises is lacking. The questions raised from the perspective of energy policy (especially regarding the access to electricity with the objective of poverty reduction or rural development) were refined by making use of concepts from literature that related to innovations and rural micro-enterprises.

Access to electricity can impact micro-enterprises by enabling the use of electric appliances, thus increasing productivity. Potentially, an increase in productivity (for example, ability to charge more cellphones) can result in more sales, thereby boosting business revenues. Even though lack of reliable data made it difficult to determine the cost of electricity in units of kilowatt-hours, detailed interviews with the entrepreneurs revealed that the volume of customers increased with an increase in electricity access.

From equation 3.2 and equation 3.4, power drawn and energy consumed can be calculated. There are two instances in calculating both power and energy, that is, the peak and the average. To calculate the peak power:

$$P_{peak} = (P)(N_{max}) \tag{6.1}$$

where P is the Power (Watts), N_{max} is the maximum number of cellphones (or lightbulbs) that they have on a given day. To calculate the peak energy consumption:

$$E_{peak} = (E)(N_{max}) \tag{6.2}$$

where E is the energy consumed (Watts-Hours), N_{max} is the maximum number of cellphones (or lightbulbs) that they have on a given day. The average power (P_{avg}) and average energy (E_{avg}) are calculated using the same equations as equation 6.1 and equation 6.2 respectively with the variable N_{max} replaced with N_{avg}, the in the average number of cellphones (or lightbulbs) that they have on a given day.

$$P_{avg} = (P)(N_{avg}) \tag{6.3}$$

$$E_{avg} = (E)(N_{avg}) \tag{6.4}$$

Category	**Power (W)**	P_{peak} **(W)**	E_{peak}**(kWh)**	P_{avg}**(W)**	E_{avg}**(kWh)**
CCS[a]	7.2	216	0.64	109	0.13
GS[b]	25	100	0.5	50	0.13

[a] Refers to Cellphone Charging Stations. The maximum number of cellphones charged on a given day were 30 while the average was 15. Peak usage was 3 hours while average usage was 1.2 hours.
[b] Refers to General Stores. The maximum number of light bulbs used on a given day were 4 while the average was 2. Peak usage was 5 hours while average usage was 2.6 hours.

Table 6.1: Power consumption averaged out through the cellphone charging stations and general stores

Though these are very rough calculations and approximate numbers based on the responses from the entrepreneurs, it is clear that the electricity consumption of the micro-enterprises is very low thus low-power solutions could essentially give a very big difference. Compared to consumption of those connected to the grid, the average daily energy consumption in Uganda is approximately 1kWh while that of the micro-enterprises is only approximately 0.13kWh. This goes to show that with low power solutions, access to electricity can bring impact to the poor.

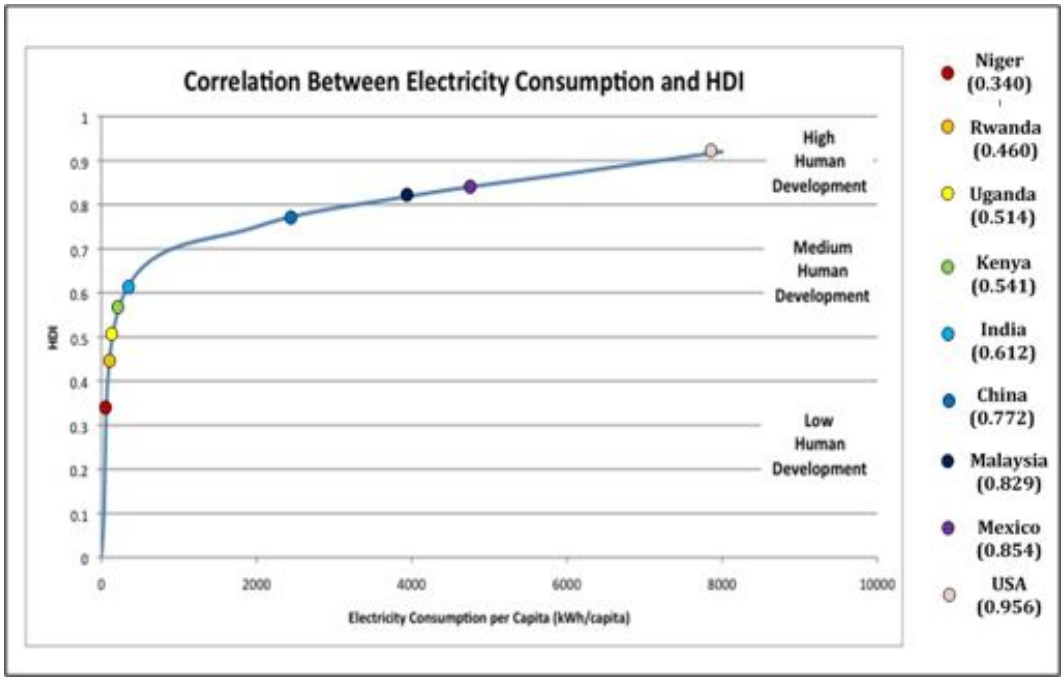

Figure 6.1: Macro level correlation between electricity and human development

From figure 6.1, if the correlation between electricity and human development was to assume a linear form, there would need to be a large increase in power production to meet a small change in the HDI. It is evident that with low power devices, the needs can be met at a very small scale and dramatically increase the HDI, thus growth and development for rural areas.

6.2 Lessons and Policy Implications from the Uganda Experience

This study helps clarify the mechanisms through which off-grid rural electrification can contribute to rural development. Access to electricity enables the use of electric equipment and appliances by the micro-enterprises, boosting productivity and revenues in clear and compelling ways. Simultaneously, access to electricity enables and improves the delivery of social and business services from a wide range of village-level infrastructure such as schools, financial institutions, and farming tools. Increased productivity and growth in revenues within the context of better delivery of social and business support services contribute to achieving higher social and economic benefits for rural communities. Another key finding relates to cost recovery. The micro-enterprises demonstrated very high costs of accessing electricity which could potentially be recovered with the implementation of more appropriate technologies.

6.2.1 Access and Impacts of Electricity Access

In this research, the segregation of the steps between access to electricity and impacts has shown that attainment of electricity generating equipment is only a first step towards impacts, and that impacts on income generation are related to the use of electricity appliances. This fact is not only relevant for the evaluation of impacts, but also directly for the entrepreneurs decisions on purchasing the equipment, which depend largely on the perceptions of benefits. As impacts can hardly be predicted, decisions for purchasing electricity generating equipment and appliances are based on experiences and intangible influences of other entrepreneurs.

The example of lighting shows that insights into actual use provide a very different picture from a daily expansion of working hours, which is commonly assumed. Despite the fact that the fifty six micro-enterprises have lighting as one of the main uses of electricity, thirty five of them only occasionally remained open in the evening,

with only fifteen regularly doing so. Light is also used during the day to improve comfort of operation. For many entrepreneurs, impacts are on wellbeing rather than on income. Therefore it can be considered that the use of electric light does bring benefits, in income for some entrepreneurs, and in other aspects for others. However, the ability to pay for such electricity services does not increase by a predictable quantity of extra daily income earned through the micro-enterprise activities, as such impacts depend on the micro-enterprise context and on assets of the entrepreneur.

6.2.2 Influence of the Characteristics of Electricity Supply

Once investment in electricity generating equipment has taken place, the costs of electricity can still have major impacts on the micro-enterprise operation. Therefore the financial capability to purchase fuel, infrastructure, and weather play a role in the impacts on the micro-enterprise. As the diffusion process of electric appliances can follow at a pace independent of access to electricity, it is likely that for many appliances, saturation has not yet been reached, as new appliances are introduced, market demands change and there is development of newer technologies.

The role of electricity in income generation can be differentiated between 'survivalist' and 'growth' micro-enterprises. For those micro-enterprises that function as survivalist, reduced cost of access to electricity contributes to the aspects crucial for generation. For those in growth category, investments in electricity equipment and appliances that can contribute to increased volumes of production are beneficial, as far as the entrepreneur has the assets to be able to access or create markets for the micro-enterprise products and services.

6.3 Answering the Research Question

The guiding question to this research was stated as: ***What are the practices in off-grid electricity access and how does this impact micro-enterprises in rural areas?***

The main findings above indicate the complexity of the answer to this question. The what aspect of the question has been answered by detailing the mechanisms that play a role in off-grid access to electricity. In viewing the 'how' part, different perspectives must be further studied. Assessing a more detailed economic analysis of the micro-enterprises could provide a better answer to the question. While it was evident that an increase in access to electricity led to increased number of customers, we cannot deduce strongly the impacts towards poverty alleviation. To achieve poverty reduction related to increase in income, the key to these mechanisms is formed by the opportunities to access affordable and reliable access to off-grid electricity and use of appropriate appliances.

From an economic perspective, poverty impacts for the entrepreneurs became evident as most likely to be non-monetary benefits, especially because trust in the community and influence from sales people. Factors that can be influenced to improve the impacts of off-grid electricity may constitute small steps, by increasing the uptake of low-risk beneficial electricity generating equipment and appliances, and by improving the micro-enterprise operation.

The benefits of the use of electricity can be improved for all entrepreneurs through the characteristics of the off-grid electricity supply. Reliability of supply is important for both use and impacts on the micro-enterprises. As social assets currently play a large role in access to electricity, and the poor typically lack the necessary assets, control of equitable access for all would improve the choices available to the poor, and thereby improve opportunities to increase income from micro-enterprise activities.

6.4 Reflections and Recommendations

As the topic of energy in poverty reduction was revived as a policy interest following the formulation of the Millennium Development Goals and the recognition of the role of energy in reaching these, motivation to pursue this research was established so as to create insights into the role of energy on poverty reduction through income generation from a small scale micro-enterprise.

The qualitative methodology in combination with an entrepreneur perspective chosen for this research was found not only to be essential for raising issues as they emerge from practice as relevant for the study, but also to allow continuous checking of the meaning of findings. As seen through this dissertation, the meaning of the findings presented in tables and plots often emerged through discussions based on the information behind the numbers. Knowledge of the micro-enterprises and entrepreneurs, and insights into the mechanisms between access to off-grid electricity and impacts proved to be an essential component of refining and adjusting the findings.

Several objectives have been identified from policy but fall in two categories:

- Increase access to capital for investments in electricity generating equipment and appliances
- Improvement of income for the poor through access to electricity and further improvement in well-being

Synthesizing the findings on the access to electricity and impacts as they influenced the several characteristics of the entrepreneur and the micro-enterprise, a short list of explicit recommendations is made.

1. Rural electricity access projects should focus on micro-credit provision, allowing the poor to purchase direct-use electricity generating equipment and appliances
2. Subsidies (from the local government) and credit based sales need to be provided

to the micro-enterprises encouraging them to purchase equipment to increase development in the village towns

3. Financing those already accessing electricity and providing services such that they can improve their productivity and expand their markets
4. Institute education for the micro-enterprise owners on effective use of the equipment, maintenance and ability to plan ahead for upgrades, focusing on long-term economic benefits
5. Priority on enabling and assisting women-owned micro-enterprises in accessing electricity due to a gender inequality
6. Improve income-generation by use of modern and appropriate technology such that there is efficiency and avoid the vicious cycle of poverty that is prominent in developing countries.

An overall recommendation is that there are no one-size fits all models of recommendations that will benefit the poor, but rather the influencing factors and the mechanisms encountered in this field research should be closely evaluated in a local context in community development. It must be taken into account that a blanket approach [47] in electricity access to reaching the poor based on an income criteria is unlikely to reach many of the poorest groups. Understanding of local micro-enterprises needs to electricity access and support using appropriate technology is the first step in support. Furthermore, demands in regard to support for finance, marketing or skills development is a another step to be considered. Institutional support in this field would benefit from creating sustainable and open contacts with entrepreneurs, and adapting business development support to identified needs.

[47] The Blanket Approach is about creating something from nothing to help those with nothing.

APPENDICES

APPENDIX A

Terminologies

A.1 List of Terminologies

Developed countries (industrial countries, industrially advanced countries): High-income countries, in which most people have a high standard of living. Sometimes also defined as countries with a large stock of physical capital, in which most people undertake highly specialized activities. Developed countries contain about 15 percent of the world's population.

Developing countries: According to the World Bank classification, countries with low or middle levels of GNP per capita. More than 80 percent of the world's population lives in the more than 100 developing countries.

Economic development: This is the qualitative change and restructuring in a country's economy in connection with technological and social progress. The main indicator of economic development is increasing GNP per capita (or GDP per capita), reflecting an increase in the economic productivity and average material wellbeing of a country's population. Economic development is closely linked with economic growth.

Economic growth: Quantitative change or expansion in a country's economy. Economic growth is conventionally measured as the percentage increase in gross domestic product (GDP) during one year. Economic growth comes in two forms: an economy can either grow "extensively" by using more resources or "intensively" by using the same amount of resources more efficiently (productively). When achieved by using more labor, it does not result in per capita income growth; when achieved through more productive use of all resources, including labor, it results in higher per capita income and improvement in people's average standard of living.

Electricity Appliance: Transforms an electricity carrier into an electricity service (for example a light bulb transforms electricity into lighting)

Electricity Generating Equipment: Transforms an energy source (such as sunlight, or diesel) into a useful electricity carrier. For example solar electricity, or a diesel generator.

Electricity Sector: The group of public and private companies, activities and installations used for the production, transmission and distribution of electricity, including the import and export of electricity.

Electricity Services: Electricity services are the functions provided through use of electricity, usually in combination with an electricity appliance. Examples of electricity services are lighting, refrigeration, processing, and communication, not necessarily involving grid electricity.

Energy Access: The following aspects are in place: Infrastructure within vicinity, connection to the location of micro-enterprise and supply is operational.

Energy Poor: Refers to those who have very little or no access to energy access, or those who do have mediocre access.

Household: A household is a social group, which resides in the same compound, share the same meals, and make joint or coordinated decisions over resource allocation and income pooling.

Human Development Index: a composite index measuring average achievement in three basic dimensions of human development: a relatively long and healthy life, knowledge and a decent standard of living. The HDI is produced by the UNDP and presented in annual Human Development Reports.

Market liberalization: Removing and abstaining from using state controls that impede the normal functioning of a market economy - for example, lifting price and wage controls and import quotas or lowering taxes and import tariffs. Market liberalization usually does not mean that a government completely abstains from interfering with market processes.

Micro-Enterprises (MEs): This term is used to refer to a very small business that produces goods or services for cash income. There is no universally accepted definition of MEs, different countries use various measures of size depending on their level of development. The commonly used yardsticks are total number of employees, total investment and sales turnover. In the context of Uganda, micro-enterprises are those engaging up to four people, in most cases family members.

Modern Energy: Refers to a variety of energy carriers including LPG, petroleum and electricity, either grid or off-grid electricity (generated by burning fossil fuels or by using alternative, renewable sources such as solar, biomass, hydro or wind).

Poverty line (national): The income level below which people are defined as poor. The definition is based on the income level people require to buy lifes basic necessitiesfood, clothing, housing and satisfy their most important sociocultural needs.The poverty line changes over time and varies by region.

Poverty line (International): An income level established by the World Bank to determine which people in the world are poor - set at $1 a day per person in 1985 international purchasing power parity (PPP) prices(equivalent to $1.08 in 1993 PPP prices). A person is considered poor if he or she lives in a household whose daily income or consumption is less than $1 per person.

Quality of life: People's overall well-being. Quality of life is difficult to measure (whether for an individual, group, or nation) because in addition to material well-being it includes such intangible components as the quality of the environment, national security, personal safety, and political and economic freedoms.

Rural Area: Refers to a locality outside of areas that are administratively managed by urban authorities. Rural areas are relatively deprived in terms of modern energy infrastructure. They are not connected to grid electricity. Rural areas are sparsely settled places away from the influence of large cities and towns. They are remote from the national grid and have no chances of accessing the grid in the near future.

Sustainable development: According to the United Nations World Commission on Environment and Development (1987), sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." According to the more operational (practice-oriented) definition used by the World Bank, sustainable development is "a process of managing a portfolio of assets to preserve and enhance the opportunities people face." Sustainable development includes economic, environmental, and social sustainability, which can be achieved by rationally managing physical, natural, and human capital.

Village Town: This term is used in the context of the micro-enterprises located in the rural areas. Primarily, the village town will consist of small buildings approximately twenty by forty feet divided into two sections. Usually the rear section is the living quarters of the entrepreneur and the front is the business center.

A.2 Exchange Rate

Ugandan Shillings: Exchange rate in the research period: 09/01/2007 to 12/31/2009

USD: average 1928 UGX/USD

EURO: average 2785 UGX/EUR

APPENDIX B

Uganda Background

B.1 Location and Size

Uganda is located in East Africa and lies across the equator, about 800 kilometers inland from the Indian Ocean. It lies between 1 ° 29' South and 4 ° 12' North latitude, 29 ° 34' East and 35 ° 0' East longitude. The country is landlocked, bordered by Kenya in the East; Sudan in the North; Democratic Republic of Congo in the West; Tanzania in the South; and Rwanda in South West. It has an area of 241,038 square kilometers, of which the land area covers 197,323 square kilometers.

The country enjoys equatorial climate with plenty of rain and sunshine moderated by the relatively high altitude. In most parts of the country, the mean annual temperatures range from 16 °C to 30 °C. Nevertheless, the Northern and Eastern regions sometimes experience relatively high temperatures exceeding 30 °C and the South Western region sometimes has temperatures below 16 °C.

B.2 Administration

The country is currently divided into 80 districts. The districts are sub divided into lower administrative units. These are counties, sub-counties and parishes. Overtime, the numbers of districts and lower level administrative units have continuously increased with the aim of making administration easier. The total number of districts increased from 56 districts in 2002 to 80 in 2007. [UBS, 2008]

B.3 Education

Uganda's education system is both formal and informal. Under the formal system, the four tier educational model is followed. This has seven years of primary education, four years of ordinary level secondary education, two years of advanced level secondary education and the tertiary level of education. Each level is nationally examined and certificates are awarded. University education is offered by both public and private institutions.

The Universal Primary Education (UPE) program was introduced in 1997 to offer free education at the primary level while Universal Secondary Education (USE) was introduced in 2007. The government also sponsors about 4,000 students every year through the public universities. The private sponsorship scheme is also operational in the public universities. University education can also be obtained from any of the private universities in the country. In addition, a large number of institutions both private and public also offer tertiary education.

B.4 Literacy

More than two thirds of the population aged 10 years and above in 2002 were literate, that is, could write or read with understanding in any language. However, wide sex disparities still exist in the literacy rates with 76% of the males being literate compared to 61% of the females. Despite the high levels of literacy, in absolute terms, over 5 million Ugandans aged 10 years and above are illiterate.

B.5 Districts Information

Uganda is divided into 80 districts across four administrative regions, Central, Eastern, Northern and Western. Most districts are named after their main commercial and administrative towns. This research covers an areas bounded by 3 districts, Kamwenge, Kabarole and Kyenjonjo.

B.5.1 Kamwenge District

Kamwenge District is a district in western Uganda. Like several other Ugandan districts, it is named after its 'main town', Kamwenge, where the district headquarters are located. Kamwenge District is part of the Kingdom of Toro, one of the ancient traditional monarchies in Uganda. It is bordered by Kabarole District to the north, Kyenjojo District to the northeast, Kiruhura District to the southeast, Ibanda District to the south, Bushenyi District to the southwest and Kasese District to the west. Kamwenge, the district headquarters lies 300 kilometers (190 miles), by road, west of Uganda's capital, Kampala.

The district covers an area of approximately 2,304 square kilometers (890 square miles). Of this, 64.1 square kilometers (24.7 square miles) is covered by open water. It is predominantly a rural district with some of the worst poverty levels in the country. The district does not have a hospital. The 2002 national census estimated the population of Kamwenge District at about 295,300, of whom 51.5% were female and 48.5% were female.[2] The annual population growth rate of the district is approximately 3.2%. It is estimated that in 2010, the population of the district is approximately 380,000. [UBS, 2008]

Agriculture is the mainstay of the district economy. In the Kitagwenda area of the district, there is fishing, some of it for commercial purposes.

B.5.2 Kabarole District

Kabarole District is a district in western Uganda. Kabarole District is part of the Kingdom of Toro, one of the traditional monarchies that are constitutionally recognized in modern-day Uganda. The district is bordered by Kyenjojo District to the east, Kamwenge District to the southeast, Kasese District to the south, the Democratic Republic of the Congo to the southwest and Bundibugyo District to the west and to the north. The biggest and busiest towns in the district in Fort Portal.

The district lies within an altitude range of 915 meters at Lake Kyoga to 3,556 meters above sea level. It has a total area of 8,318.2 square kilometers of which only 0.87% is covered by open water (mostly Lake George), making the district the least endowed with surface water resources in the region.In 2002, the population of Kabarole District was estimated at 359,200 with a population growth rate of 3.0% annually. It is estimated that in 2010, the population of will be approximately 455,000.

Subsistence agriculture and animal husbandry are the main economic activities in Kabarole District. The district is one of the five districts in Uganda where wheat can be grown. Livestock is the second economic activity and is concentrated in the counties of Kyaka, Kibale, Burahya, Mwenge, Bunyangabu and Kitagwenda. Commercial fishing occurs on about 30 of the 52 crater lakes, scattered in Kabarole District. The main fish species harvested from the crater lakes is the small Haplochromines (Nkejje). Fishing, mainly of Protopterus aethiopicus (Lung fish), is also carried out in a number of wetlands. Aquaculture is practiced with increasing frequency in the district and in 2005 there were over 300 fish ponds stocked with tilapia and mirror carp species. [UBS, 2008]

B.5.3 Kyenjonjo District

Kyenjojo District is a district in western Uganda. Like most other Ugandan districts, it is named after its 'main town', Kyenjojo, where the district headquarters are located. It is bordered by Kibale District to the north, Mubende District to the east, Kiruhura District to the southeast, Kamwenge District to the south and Kabarole District to the west. The district headquarters at Kyenjojo are located approximately 274 kilometers (170 miles), by road, west of Kampala, Uganda's capital and largest city.

The district covers an area of approximately 4,000 square kilometers. About 912 square kilometers of land is forest; 414.6 square kilometers under wetlands and the remaining under cultivation or available for cultivation. The 2002 national census estimated the population of the district at about 380,400. The annual population growth rate of the district is estimated at 3.0%. It is estimated that the population of Kyenjojo District in 2010 will be approximately 481,000. [UBS, 2008]

Agriculture is the main economic activity in the district, with growth of many different crops. Chimpanzee tracking is common in Kyenjonjo district and a good source of income from tourism.

APPENDIX C

Interviews

C.1 Interviews

In this study, I combine quantitative and qualitative methods, including informal surveys, intra-business energy allocation studies and historical (stories told) analysis, to analyze the impact of practices in off-grid electricity access among micro- enterprises in rural western Uganda. The data collected is compiled into a database for later analysis. The interview questions are divided into six sections.

C.1.1 Demographics

The following information is collected by asking direct questions regarding the micro-enterprise:

- Location (District and Village Town)
- Micro-Enterprise Identifier (Generated Sequentially as an identifier)
- Micro-Enterprise Name
- Business Category
- Years in Business
- Number of Employees
- Hours of Operation

The following information is collected by asking direct questions regarding the entrepreneur:

- Entrepreneur's Name
- Entrepreneur's Age
- Entrepreneur's Sex
- Entrepreneur's Phone Number
- Entrepreneur's Level of Education

C.1.2 Products and Services

The following information is collected by asking direct questions regarding the products and services offered by the micro-enterprise:

- Product and/or Service Provided
- Buying Price
- Selling Price
- Quantity (per day)
- Number of Customers (per day)

C.1.3 Electricity Generation

The following information is collected by asking direct questions regarding the generation of electricity for the micro-enterprises, which occurs either at the site, or at a different site:

- Generation Equipment (Only 4 types noted, diesel generators, petrol generators, solar PV and battery systems)
- Fuel Type
- Fuel Consumed Per Day (in Liters, depending on the type of generator)
- Status at Purchase (New or Used)

- Maintenance (Regular)
- Length of Ownerships
- Length of Battery before next charge
- Fuel Cost (Per liter)
- Frequency of Fuel Purchase (how many times in a week do they purchase fuel)
- Transportation Method
- Transportation Cost (round trip)
- Other notes relevant

C.1.4 Electricity Use

The following information is collected by asking direct questions regarding the use of electricity within the micro-enterprises:

- Electricity Use
- Electrical Appliance
- Wattage (Ratings)
- Duration of Use (daily)
- Length of Ownership
- Status at Purchase (New or Used)
- Maintenance (Regular)
- Other notes relevant

C.1.5 Relevant Notes

The following information is collected by asking direct and indirect questions regarding different factors that affect the micro-enterprises and the entrepreneur:

- Weather and Environmental Restrictions
- Infrastructure

- Cultural Awareness and Restrictions
- Willingness to Pay for Electricity Access
- Importance of Electricity
- Sources of Capital
- Purchasing Strategies
- Other Comments

APPENDIX D

Energy Models

D.1 Basic Energy Model

In thinking through most of the research, a basic energy model was created to help in idealizing solutions for off-grid electricity access.

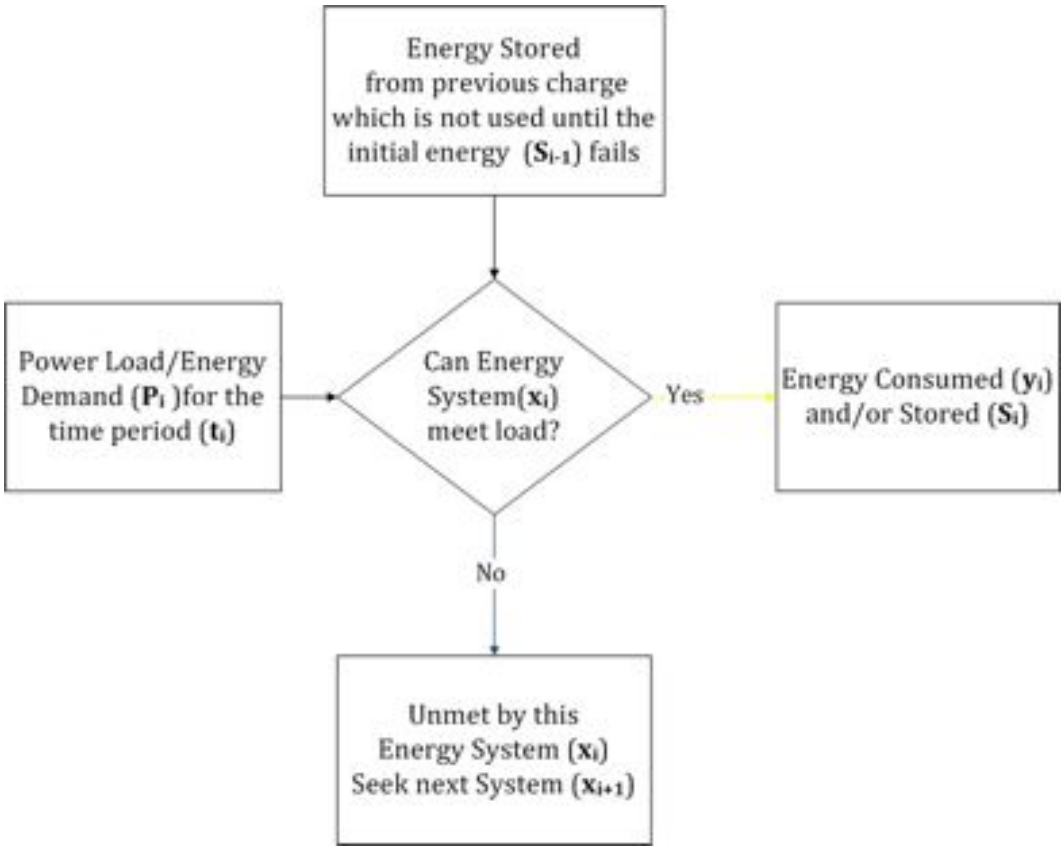

Figure D.1: A basic energy model.

D.2 Independent Power Producer Nexus - Detailed

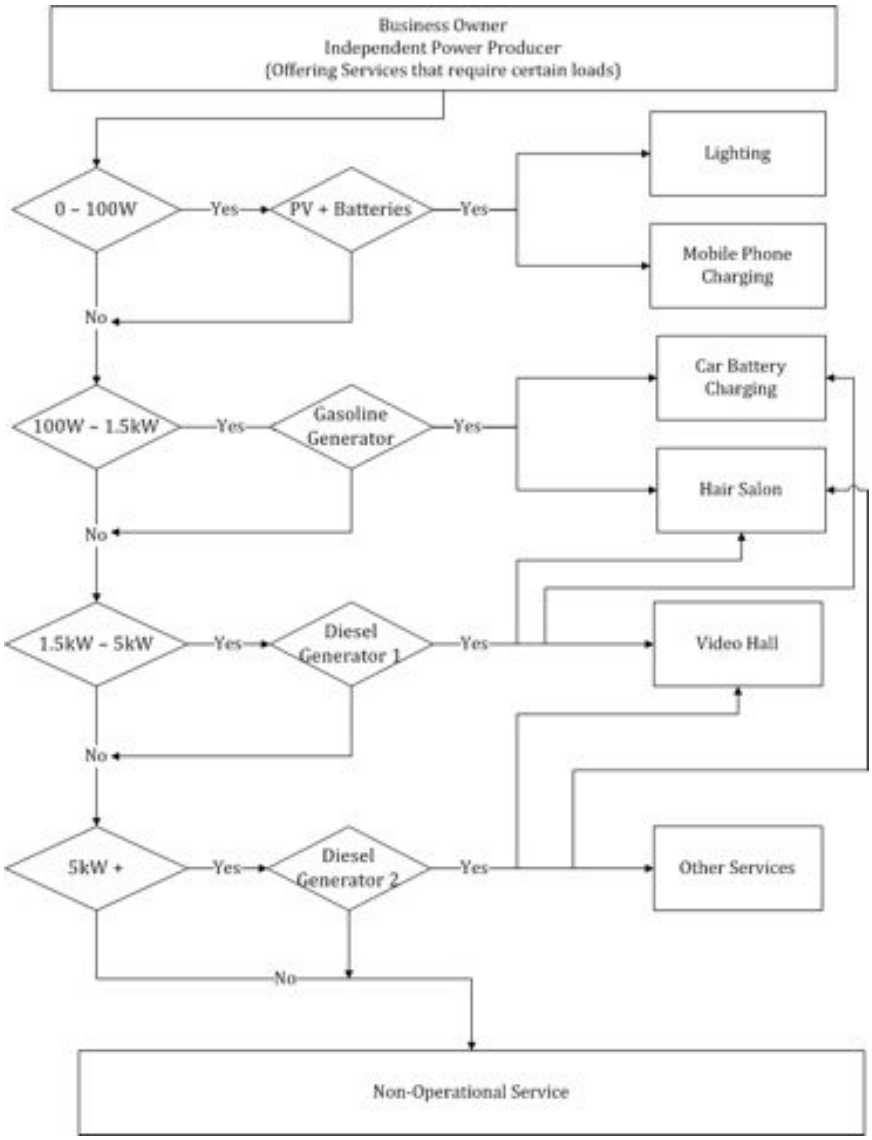

Figure D.2: A more detailed schematic diagram showing the flow of usage among the different ventures based on the need at the time. [Special thanks to Abigail Mechtenberg]

D.3 MPALA Research Centre and Ranch

The Mpala properties in Laikipia, Kenya were purchased by Sam Small in 1952 and bequeathed to his brother George in 1969. George Small focused his energies and resources on conserving the habitats and wildlife of Mpala and providing healthy livelihoods for Mpalas employees and families. In 1989 George created the Mpala Wildlife Foundation and the Mpala Research Trust to fund the activities necessary to achieve his vision. In accordance with George Smalls mission, the Foundation supports the wildlife conservancy, a primary school for employees children, a community outreach program which includes the Mpala Mobile Clinic, as well as a working cattle ranch that successfully coexists with an abundance of wildlife. The Foundation contributes to the Mpala Research Trust that supports and directs the Mpala Research Centre, a well respected, international research facility located on the Mpala property. Mpala facilitates and exemplifies sustainable human-wildlife co-existence and the advancement of human livelihoods and quality of life. This is done this through education, outreach, and by developing science-based solutions to guide conservation actions for the benefit of nature and human welfare.

Mpala is located about 75KM from Nanyuki town, the closest to grid electricity. While they have funds that help to run a 30KVA diesel generator, a 22KVA petrol generator and several solar panel installed on the different buildings, those that suffer tremendously are the employees living at the MPALA village. They rely on batteries which have to be brought to the charging station, where the priority is charging batteries for the researchers. Thus finding a solution to meet the needs of the employees is likely to have a profound effect on success and efficiency during the work hours. The need for better energy solutions are eminent, especially with the increase in cost of both diesel and petrol.

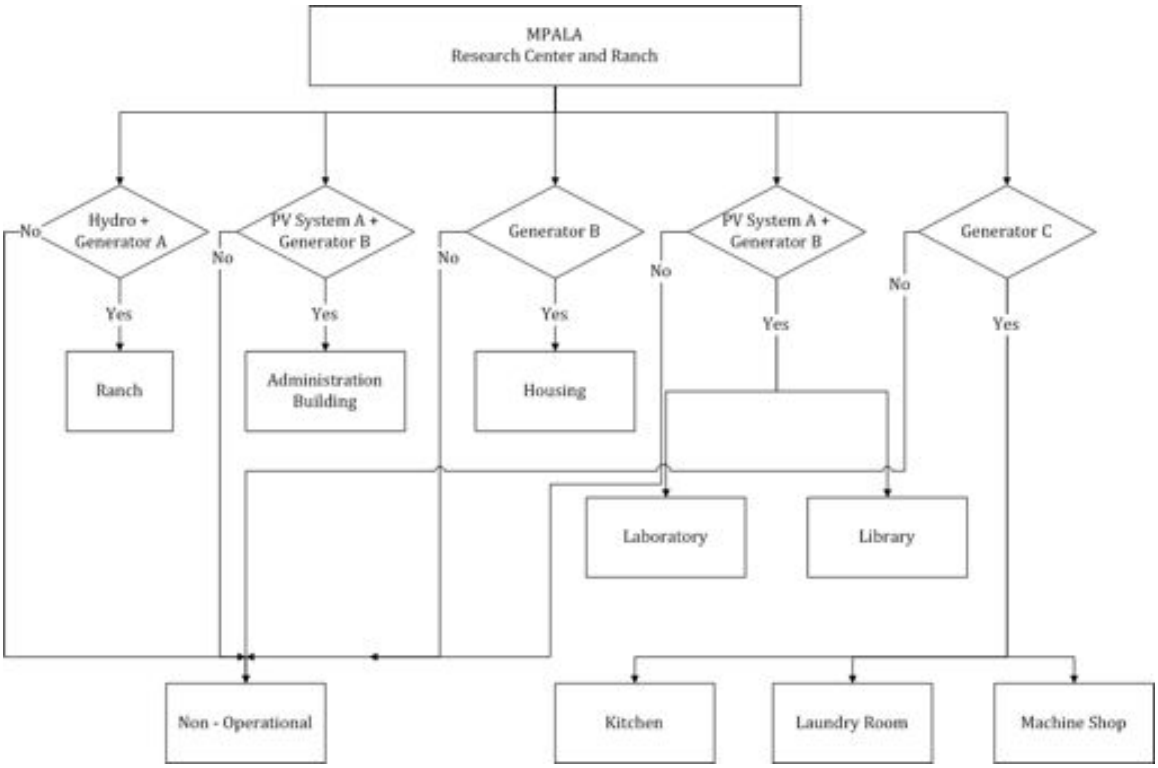

Figure D.3: A simple proposed layout of MPALA's energy scheme

Figure D.4: Diesel Generator at MPALA

Figure D.5: Petrol Generator at MPALA

APPENDIX E

Equipment and Appliances

E.1 Electricity Generating Equipment and Appliances

Figure E.1: Bicycle generator lighting up a bulb. Built by the local technicians at St. Joseph's Technical School

The following is a representation of innovation, where a barber shop and video hall are both in the same place, typically hair is cut when they are watching the TV.

Figure E.2: Appliances at a video hall

Figure E.3: Appliances at a barber shop

Figure E.4: Appliances at a general store

Figure E.5: Appliances at a cellphone charging station

APPENDIX F

Micro-Enterprise Views

F.1 Detailed Micro-Enterprise View

Small and Medium Enterprises (SMEs) contribute greatly to the economy of Uganda, regardless of their level of development. In 2001, Uganda was estimated to have about 1 million enterprises classified as MSMEs and forming 90% of Uganda's private sector. MSMEs employ approximately 1.5 million people equivalent to 90% of total non-farm private sector workers [UBS, 2007].

SMEs suffer difficulty in accessing (i) appropriate technology, (ii) skills and education, (iii) financing, (iv) business information and (v) land. The constraints make it difficult for MSMEs in Uganda to develop their productive capacities, maximize their competitiveness and contribute to sustainable economic growth. Furthermore, appropriate technology, skills, education and information, are essential for the sustainable growth of micro-enterprises.

Figure F.1: Inside a General Store

Figure F.2: Outside View of a Restaurant

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