

# **ASSESSMENT OF THE SOCIO-ECONOMIC IMPACT OF SOLAR MINI-GRIDS IN ZAMBIA**

**A comparative analysis of  
End-users and Non-end-users**

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## **ASSESSMENT OF THE SOCIO-ECONOMIC IMPACT OF SOLAR MINI-GRIDS IN ZAMBIA** <sup>1</sup>

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## EXECUTIVE SUMMARY

The aim of this paper was to assess the socio-economic impact of access to solar mini-grids on the livelihoods of end-users in Zambia. The study employed a qualitative and quantitative research design, utilising control and experimental groups. The study demonstrated that access to solar mini-grids contributed to the reduction of the average monthly household lighting energy expenditure. Additionally, the access to solar mini-grids also positively contributed to the increase in household income through the engagement in different economic activities.

The findings revealed that households' monthly energy expenditure reduced to K186.86 compared to K564.44 before connecting to the mini-grid, reflecting a 66.9% reduction. This was mainly due to decreased expenditure on lighting. The arrival of the mini-grid resulted in a shift of 98.6% of households from traditional sources of energy for lighting to electricity. The overall average household income increased to K2,417.82 after connecting to the solar mini-grid, a 42.8% increase from K1,693.15 before access. This was attributed to households engaging in income generating activities.

The study also found that most consumers expressed satisfaction with the quality of services provided by mini-grid operators. Specifically, 95.5% of households, 85% of small and medium enterprises (SMEs), 50% of schools, and 100% of health facilities were satisfied with the quality of service provided by the solar mini-grids. Despite this, 65% of households reported that solar mini-grid operators should increase the load capacity of the grid to enable the use of more appliances such as cooking stoves and pressing irons.

The research findings showed that the solar mini-grids had an impact on the shift towards the use of electricity as the main source of energy for lighting, while there was no significant change in relation to other uses (i.e., cooking and heating). Firewood remained the main energy source for cooking at 85.6% among households with a mini-grid connection and 95.8% for households without access to electricity. Meanwhile, charcoal was the main energy source used for heating at 53.3% for households connected to the mini-grid and 57.1% for those without mini-grid connection.

The study makes the following recommendations:

1. The government should consider increasing financial support to the Rural Electrification Authority (REA) to enable the roll out of more solar mini grids in rural areas.
2. The government should consider offering more incentives for the private sector to set-up more solar mini-grids in remote areas which do not have access to the national grid.
3. The ERB should undertake an awareness and sensitization programmes for solar mini-grid consumers on their right to escalate their complaints when they are not satisfied with the complaints handling procedure of the mini-grid operator.
4. The ERB should conduct a future study with a wide scope to include different technologies to ensure an in-depth understanding of the socio-economic impact of mini-grids in general on end-users across the country.

# CHAPTER ONE: INTRODUCTION

## 1.1. INTRODUCTION

This paper presents the study findings of the Energy Regulation Board's (ERB) survey on the socio-economic impact of access to solar mini grid on the livelihoods of end users based on a case study of Chitandika and Katamanda villages of Chipangali district in Eastern province of Zambia. An electrical mini-grid is an electricity power generation and distribution system that provides electricity to a few customers in a remote settlement or brings power to hundreds of thousands of customers in a town or city (World Bank Group, 2019), usually mini-grids exist in areas that are far away from the main national grid.

Mini-grids facilities are playing a very important role at increasing access to electricity especially in the rural areas of Zambia. Zambia's rural access to electricity stood at 4.4%<sup>2</sup>, as a sector regulator, the ERB has actively taken interest in the promotion of mini-grids in the country to support government's efforts of increasing access to electricity. For instance, the ERB is developing the mini-grid regulatory framework. The aim is to attract investment in the sector by lowering the cost of regulation but also ensuring that the developer earns a reasonable rate of return. The number of licensed mini-grids in the country has been increasing and stood at eighteen in 2023 from two in 2014. This study reveals that mini-grids have had a profound impact on the livelihoods of end users. Additionally, the paper offers policy recommendations for the growth of mini-grids in the country.

The overall structure of the study takes the form of seven chapters. The first chapter outlines the introduction, providing the study background, study objectives, research questions, and justification for the study. Chapter two dwells on the empirical and theoretical literature. Chapter three focuses on the methodology employed in the study, highlighting the sampling methods, the target population, and data collection techniques. Chapter four provides a discussion of the findings on the sources of energy for consumers, while chapter five presents the social and economic impacts. Chapter six outlines the consumer perceptions on mini-grids, while Chapter seven provides a conclusion and recommendations.

## 1.2. BACKGROUND

Access to reliable and affordable electricity is a cornerstone of socio-economic development, transcending the boundaries of urban centers and extending to the far reaches of rural communities. Ebhota and Tabakov (2018) argue that electricity serves as the fundamental building block and essential conduit for fostering economic progress. Energy has been identified as an important driving force for economic development in Zambia, and the government has declared its commitment to developing and maintaining energy infrastructure and services. The Government of Zambia through Vision 2030 set a target for the energy sector to attain universal access to clean, reliable and affordable energy at the least economic, fiscal, social and environmental costs for all Zambians by 2030. To attain this target, the share of wood fuel usage needs to reduce by 40 percent and increase the use of renewable alternative energy sources by 2030. The development of solar mini-grids has been identified as one way of reducing the use of bio-mass<sup>3</sup>.

Zambia's electricity generation is dominated by 84% hydro which is prone to adverse effects of climate change such as long hours of loadshedding due to reduced water levels. In 2016, the ERB estimated the cost of unserved energy due to load shedding at US\$ 0.95/kWhlos (kilowatt hour lost)

<sup>2</sup> <https://www.usaid.gov/powerafrica/zambia#:~:text=National%20access%20to%20electricity%20averages,for%20all%20Zambians%20by%202030>

<sup>3</sup> [https://www.nor.gov.zm/?wpfb\\_dl=44](https://www.nor.gov.zm/?wpfb_dl=44)

for small scale enterprises. The use of solar mini-grids provides alternative energy sources in line with the National Energy Policy of 2019 and has great potential of contributing to the attainment of Vision 2030.

In November 2023, the number of licensed mini-grids in the country stood at eighteen from two in 2014. Among the developers include Standard Micro-grid, Engie Power Corner, Zengamina Power Limited, and Muhanya Solar. Examples of such mini-grids are the; Chitandika Solar mini-grid (SMG), Chibwika solar mini-grid, Katamanda solar mini-grid and the Mugurameno (Standard Micro-grid) Solar mini-grid. The Chitandika SMG, with its capacity of 28.35 kWp, serves as an energy source for 151 households, two schools, one health center, and various commercial entities such as saloons and barber shops. The Chibwika SMG is 32.4kWp capacity plant located in Northwestern province and supplies electricity to 108 households, a school and a rural health centre. The Katamanda SMG has a total power capacity of 51.8kWp located in Chipangali district of Eastern province and services 273 households, two schools and a rural health centre. Standard Micro Grid (SMG) owns and operates a 14kWp Mugurameno solar mini-grid in Chief Chiawa area of Chirundu district. The Mugurameno solar mini-grid has brought power to 11 households, a school, and five local businesses (Kapole, Mudenda and Jain, 2023). These solar mini-grids represent beacons of progress in their respective communities, yet they also underscore the intricacies of achieving economic sustainability and meeting the diverse needs of end users.

As rural electrification drives toward a brighter future, it was imperative to ascertain whether these solar mini grids are not only catalysts for immediate change but also enablers of long-term economic growth. In order to achieve the foregoing, the ERB undertook a study with the aim of ascertaining the impact of solar mini-grids on the social and economic lives of the end users. The research was undertaken, driven by the ERB's mandate as outlined in the Energy Regulation Act No.12 of 2019 part n and o which states: *to initiate, conduct and promote research surveys, studies, training and investigations in the energy sector; and promote, development and the use of new and appropriate technologies in the energy sector.* Furthermore, the ERB is also mandated to make recommendations to the Minister on various issues in the energy sector under section (q) of the Energy Regulation Board Act of 2019. Consequently, this paper envisaged developing policy recommendations for government consideration on the impact of solar mini-grid on end users in the country.

### 1.3. PROBLEM STATEMENT

The deployment of solar mini-grids in rural areas has introduced a new paradigm of electricity access, promising to uplift the lives of end-users through enhanced energy availability. However, the actual impact of these mini grids on the end-users within these communities remains inadequately understood especially in Zambia. There is a critical knowledge gap regarding the extent to which mini-grids have succeeded in improving the quality of life, enhanced economic opportunities, and overall well-being of the end-users in these remote settings. This lack of clarity hampers the formulation of effective policies and regulatory interventions that can maximize the positive influence of mini-grids on the lives of the end users. Ayhan, Falchetta and Steckel (2022), encourage additional research to assess the impact on well-being resulting from mini-grids electrification. Addressing this gap is crucial for ensuring that future rural electrification efforts are tailored to deliver meaningful and sustainable improvements to the end-users' livelihood. As the ERB develops and plans to implement mini-grid regulations to promote investments in mini-grid development in rural areas, it becomes imperative that an assessment of the socio-economic impacts of solar mini-grids is conducted.

## 1.4. GENERAL OBJECTIVES

The general objective of the study was to assess the socio-economic impact of access to solar mini grids on the livelihoods of end users in Chitandika and Katamanda districts.

### 1.4.1. Specific Objectives

The specific objectives of this study were:

- i. To assess the socio-economic impact of solar mini-grids on end-users, in terms of changes in consumers' income, energy expenditure, and entrepreneurial activities brought about by a solar mini-grid;
- ii. To explore consumers' perceptions on the quality and reliability of the service provided by the solar mini-grid;
- iii. To examine the impact of a solar mini-grid on the lifestyle (social wellbeing) of end-users; and
- iv. To assess changes in consumers' sources of energy (lighting, cooking, and heating)

## 1.5. RESEARCH QUESTIONS

1. Have solar mini grids brought changes in households' income, expenditure and economic activities?
2. How do consumers perceive the quality and reliability of services provided by solar mini grids?
3. How has access to mini grid affected consumers' choices of sources of energy for lighting, cooking, and heating?
4. How have Solar mini grids affected health, education and entrepreneurial activities?

## 1.6. JUSTIFICATION OF THE STUDY

There has been a notable growth in the number of ERB licensed mini-grids in the country from two in 2014 to eighteen in 2023. This growth has been supported by the favorable government policy and incentives to encourage the use of alternative renewable energy sources in the country. Policies include the National Energy Policy of 2019 and the Renewable Energy Strategy. Fiscal incentives include the removal of customs duty and value added tax on solar panels through the substantive customs duty rate in 1999<sup>4</sup>.

At regulatory level, the ERB is developing the Renewable Energy Regulatory Framework to support the investments and operations of mini-grids in the country. This aims at supporting the transition of renewable energy in the country. The Mini-grid Regulatory Framework will provide guidelines for the regulation of different categories of mini-grids. However, there has never been a study conducted to assess the social and economic impact of mini-grid on the lives of end-users in Zambia. The existing literature has focused on the financial, technical, environmental, and social sustainability of solar mini-grids in Zambia (Kapole, Mudenda and Jain, 2023). Comprehensive research is required to bridge this knowledge gap and provide empirical insights into the tangible changes experienced by the beneficiaries. Understanding the impact on end-users' lives that are most affected by solar mini-grids allows for regulatory and government policy direction that can yield maximum socio-economic consumer benefits. Additionally, solar mini-grids offer alternative energy sources from the hydro electricity generation that is prone to the negative impact of climate change.

Therefore, this study aimed at assessing the socio-economic impacts of solar mini-grids on end users. Through this study, the ERB aimed to uncover the benefits and challenges that come with the mini-grids, valuable insights that might inform policy decisions, guide sustainable energy strategies, explore possible regulatory interventions and highlight the challenges faced by the consumers.

<sup>4</sup> <https://www.moe.gov.zm/wp-content/uploads/2022/05/ACE-TAF-Customs-Handbook-for-Solar-PV-Products-in-Zambia-April-final.pdf>

## CHAPTER TWO: LITERATURE REVIEW

The chapter describes the theoretical and empirical literature review in line with the study objectives. It is arranged into two main sections: section 2.1 discusses the theoretical framework that guides consumer behavior in relation to programme intervention. Section 2.2 presents an empirical study of rural electrification in relation to the socio-economic impacts on consumers.

### 2.1 THEORETICAL FRAMEWORK

#### 2.1.1. *Theory of Change*

The Theory of Change (ToC) is a systematic and visual framework that outlines the causal pathway of how a specific intervention or program is expected to bring about desired outcomes and impacts. It helps to clarify the logic and assumptions behind the sequence of events leading from inputs and activities to the intended changes in a specific context. In the context of this study, it signifies the positive and transformative changes that the availability of electricity brings to rural communities. Impacts could include poverty reduction, increased social equity, improved livelihoods and sustainable development. The Theory of Change framework distinguishes between short-term, intermediate, and long-term outcomes. In rural electrification, short-term outcomes might include immediate access to lighting and phone charging, while intermediate and long-term outcomes could involve improved educational opportunities, enhanced income generation and community development (Conner, 2015).

#### 2.1.2. *Theory of Consumer Behavior*

The Theory of Consumer Behavior is a fundamental concept in economics that seeks to explain how individuals make consumption choices based on their preferences and budget constraints. It's grounded in the idea that consumers aim to maximize their satisfaction or utility by allocating their limited resources (such as income) among various goods and services (Pindyck and Rubinfeld, 2017). This theory considers both the direct and indirect impacts of changes in factors like prices, income, and preferences on consumers' consumption decisions.

In the context of rural electrification by mini-grids, the Theory of Consumer Behavior was applied to understand how the availability of electricity through mini-grids influences households' consumption patterns and economic behaviors.

#### 2.1.3. *Service Quality Theory*

The Service Quality Theory aims to understand how customers perceive and evaluate the quality of services provided by businesses or organizations. It emphasizes the importance of meeting or exceeding customer expectations and considers various dimensions that contribute to the overall assessment of service quality (Parasuraman et al., 1988). This theory has been widely applied in the context of various industries, including telecommunications, healthcare, hospitality, and utilities.

In the context of rural electrification by mini-grids, the Service Quality Theory was relevant in assessing how households and communities perceived the quality of electricity services provided through mini-grids. One dimension of service quality is the reliability and availability of the service. For rural electrification, this relates to the quality of electricity supplied through mini-grids.

## 2.2 EMPIRICAL LITERATURE REVIEW

Rural electrification is well renowned as one of the important requirements in uplifting living standards of the geographically and economically disadvantaged communities in developing countries (Chaurey et al., 2004; Bhattacharyya, 2005). Access to modern forms of energy and electricity by rural communities, especially in developing countries, has gained considerable attention.

The empirical literature on rural electrification encompasses issues on access and affordability; success stories and problems, subsidies, social, economic and environmental impacts, project planning, design and implementation.

This chapter highlights some of the important issues discussed in various international literature relevant to this study.

### 2.2.1. Consumer Perception

Creating value for the end-user is particularly important for project acceptance and the sustainability of a scheme once it has been handed over to the local community. This is in line with Woo (1992) who states that “(value is) what is of true worth to people in the broad context of the well-being and survival of individuals, and by extension, of the species as a whole”.

Understanding the perceived value (what is important) to the individual consumer as well as to the community is important. It will aid to appreciate the consumers’ real motivations which may include the flexibility of the power output and the sense of safety electricity provides through street lighting. However, as highlighted by Zeithaml (1988), Woodruff (1997), and Holbrook (1999), the degree of value differs among consumers. In as much as the service provided (electricity) remains the same but the extent to which the service is valued and perceived can be different. Some strands of this perceived value are;

- i. Emotional value - The emotional value refers to non-cognitive and unconscious decisions that are made based on, for example, childhood experiences (Sheth et al., 1991). Some characteristics that can be linked to emotional value are: association, fun, memorability, and safety. In the context of rural electrification, association may refer to one’s sense of connectivity towards a different class, culture, or people that use electricity. For example in Kenya people felt a desire for Western lifestyle and longed for a light switch and a permanent bulb in their home (GIZ EnDev, 2010). Fun can be two-fold, seen as: (a) fun with the family (or on your own), watching TV, listening to music or fun with ‘new’ equipment (object), light switches or TVs and (b) fun through the ability to socialise with peers into the late evening hours, for example. This in turn may lead to memorable moments. Additionally, electricity may provide a sense of security through improved lighting.
- ii. Sign Value - Another aspect of value proposed by the sociologist Baudrillard (1998) is sign value. The sign value refers to the prestige (social status) of the product or the service rather than the value of the actual product of service, its function, or the user value derived from it (Baudrillard, 1998). Having an electric light, for example, can signify a higher social status within the community. A recent study has shown that one of the perceived benefits from electricity in rural villages is the improved social status (Matinga and Annegarn, 2013). This is in line with Veblen (1953) who highlights that goods may be valued because of the prestige that comes with them (Veblen and Mills, 2005).

- iii. Extrinsic value - rural electrification can be classified as an extrinsic value (also known as instrumental value or contributory value), as it leads to the accomplishment of further outputs and is not an end in itself (intrinsic value) when seen from an end-user perspective (Holbrook, 1999).
- iv. Traditional/Cultural value - According to OED (2013) culture can be defined as “the distinctive ideas, customs, social behaviour, products, or way of life of a particular nation, society, people, or period”. Tradition refers to the transmission of statements, beliefs, rules, and customs that are carried forward from the past but are still followed in current culture (OED, 2013). Rural electrification is considered to fulfil the requirement for development intervention through, for example, improved health and education (IFC, 2010). However, while technology may act as an enabler of better health and education, tradition may be a barrier to its successful adoption as villagers continue to cook using firewood and children continue to collect the firewood (Pereira et al., 2011).

### **2.2.2. Economic well-being**

Rural electrification generates substantial and favorable changes in economic welfare and is deemed, by most scholars, a prerequisite for economic growth. The general economic impact is mostly measured in terms of growth of industrial activity, productivity and employment in the rural community. The impact of rural electrification on non-agricultural activities was found to be positive but weak by some studies (Samanta and Sunderama, 1983; Herrin, 1983; Djeflat, 1985) and substantial in others (Barkat et al., 2002). A study conducted in Kenya found substantial linkages between rural electrification and rural economic development in sub-Saharan Africa (Kirubi, et al., 2009). In addition to enhancing the productivity of SMEs, the study revealed that rural electrification contributed to mechanization of agriculture, facilitated trade and commerce, attracting and retaining skilled health workers, and supported improved delivery of services in local schools.

A study conducted by the World Bank in the Philippines revealed that small home businesses were more active and productive in areas with electricity (World Bank, 2008). Evidence from a number of national-level studies shows that rural electrification provides similar results. In a similar study conducted in Kenya, it was evidenced that access to electricity can impact small home businesses by enabling the use of electric tools and equipment, thus increasing productivity per worker. Potentially, an increase in productivity (i.e., the quantity and quality of goods made) can result in more sales, thereby boosting home business revenues (Kirubi, et al., 2009).

Findings from other empirical literature show how energy and household welfare relate. Khandker et al. (2013), shows that grid electrification has significant positive impacts on households' income, expenditure and educational outcomes. A study by Dinkelman (2011) estimated the impact of electrification on the employment growth of rural households. The study found that electrification significantly raises female employment within 5 years. Akpan et al. (2013) show that, on average, enterprises in communities connected to the electricity grid are 16.2 per cent more profitable than enterprises in communities not connected to the grid, and the use of gensets in providing backup electricity makes microenterprises more profitable.

In yet another study by Khandker et al. (2013), rural electrification is shown to increase labour supply, household income and expenditure (Osanyinlusi et al. 2017). But the larger share of the benefits accrues to wealthier rural households, with poorer ones having a more limited use of electricity. The study showed that a restricted supply of electricity, due to frequent power outages, negatively affects both household electricity connection and its consumption, thereby reducing the expected benefits of rural electrification.

### 2.2.3. *Social well-being*

Most scholars agree that rural electrification has positive bearings on social amenities such as health centers, educational facilities, clean drinking water, entertainment venues, and shopping destinations. Barnes (2004) reports that in Costa Rica after the electrification of rural areas, significant social improvements took place, such as; the number of education institutions with lighting and night classes increased considerably, new hospitals were set up and the number of health centers increased. A study conducted in Peru also found a positive association between rural electrification and the number of hours that school-going children spend studying at home, allowing greater opportunity for improving their academic performance (Aguirre, 2017).

It is expected that with electricity and in turn better lighting, the extended evenings would be spent in socially productive ways. Most impact studies agree that there have been positive changes with families spending more time together. For example, Djeflat, (1985) found that many households have changed their way of spending their evenings after electrification. However, Lim (1984) concludes that electricity had not given rise to important changes in the life-style of Malaysian villagers.

In a study conducted in eight counties of Kenya (Mudi, 2020), the social exclusion theory was used to explain how lack of electricity excludes individuals in rural areas from using this important resource in enhancing income, employment, healthcare, knowledge and skills. The social exclusion theory explains what can happen when people or areas face a combination of socially interrelated problems, such as lack of electricity, poor healthcare, unemployment, discrimination, poor skills, low incomes, poor housing, high crime and family breakdown (Social Exclusion Unit, 2004). Depending on how severe the social exclusion is in a particular area, it calls on the responsibility of society and the government to ensure equal opportunities such as equal access to cheap energy, to education, to healthcare, to the labor market and to the judicial system (Saraceno, 2002). In the Kenya study, the researcher used the social exclusion theory to explain that rural electrification can be used as a key means to tackle social exclusion, poverty and inequality that may ultimately enhance well-being of communities.

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.1 METHODOLOGY

The choice of methodology was largely dependent on survey objectives, desired level of disaggregation of survey results as well as financing considerations. This study employed the use of both quantitative and qualitative research design. According to Abili (2009), quantitative research entails measuring variables and providing findings in numerical form. Research findings are expressed through significance text, confidence intervals, and mathematically proven relationships. In addition, he characterizes qualitative research as a paradigm that is used to learn about people's actions, thoughts, knowledge, and emotions. Such a study aims at understanding and explaining a phenomenon that focuses on "why" and "how" questions as well as in depth and detailed "what" questions<sup>5</sup>. It is noteworthy that numerous researchers, including Abili (2009), concur that a study may incorporate a combination of qualitative and quantitative paradigms. This study was based on both qualitative and quantitative paradigms. On one hand, words are used in describing and explaining relationships between variables which make it qualitative research. On the other hand, some numerical data was collected and analyzed using descriptive statistics.

In order to assess the socio-economic impact on the livelihoods of end users, the study utilized the use of control and experimental groups. The experimental group refer to consumers in an area with access to solar mini-grid services. Meanwhile, the control group were consumers in areas located close to the experimental group and with similar characteristics except that they had no electricity access. In this study, the experimental groups are Chitandika solar mini-grid and Katamanda solar mini-grid, while the control group was Malonga village. All the villages are located in Eastern province.

## 3.2 TARGET POPULATION

The target population is the customer bases for each of the solar mini-grids in Chitandika and Katamanda villages and the households without access to electricity in Malonga village. According to Engie Power Corner, Chitandika solar mini-grid had 207 customers, whereas the Katamanda solar mini-grid had a customer base of 311. These were further subdivided into households, non-residential (i.e. schools and health facilities) and small-scale enterprises (SMEs).

### 3.2.1 Sampling frame

The customer databases as provided by the respective solar mini-grid operators were used as sampling frames for the study. The sampling frame constituted the number of customers by category type and was used to select respondents.

### 3.2.2 Sampling method

The study employed a probability random sampling for households in the experimental groups. Meanwhile, a census approach was undertaken for the non-residential customers due to the small population size. Furthermore, purposive sampling was adopted for the control group.

<sup>5</sup> Abili, C. (2009). *Abili (2009), 'Demand, segmentation and rationing in the rural credit markets of Puri'. Dissertation.* Uppsala: Department of Economics, Uppsala University

### 3.2.2.1 Sample size determination

The sample size for households in the experimental groups was determined using the Taro Yamane formula;

$$n = \frac{N}{1 + N(e)^2}$$

Where;

$n$  = sample size

$N$  = Population size

$e$  = margin of error

The formula assumes that;

$P$  = Indicator level = 50

$Z$  = Statistic for a level of confidence = 1.96 (95%)

The study's sample size per customer category is as shown in the table below.

**Table 1: Distribution of number of customers of solar mini grids and sample size by location**

Location	Households		Schools		Clinics		Business	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
Chitandika	207	36	2	2	1	1	8	8
Katamanda	311	44	2	2	1	1	0	0
Malonga Village	Unknown	48	N/A	N/A	N/A	N/A	N/A	N/A
<b>Total</b>	<b>518</b>	<b>128</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>8</b>	<b>8</b>

### 3.2.2.2 Sample allocation

An important factor when determining the efficiency of stratified sampling is the way the sample is allocated to each stratum. For purposes of this study the square root proportional allocation method was used to allocate the sample to each stratum.

Where:

$$a_h = \frac{\sqrt{Y_n}}{\sum_{h=1}^L \sqrt{Y_h}}$$

$a_h$  = ratio of the square root of the measure of size of the stratum to the sum of the square root of the measure of size of all strata

$\sqrt{Y_n}$  = Square root of the measure of size of the stratum

$\sum_{h=1}^L \sqrt{Y_h}$  = Sum of the square root of the measure of size of all strata

### 3.2.2.3 Weighting procedure

Sampling weights are needed to compensate for unequal selection probabilities, non-coverage, nonresponse, and for known differences between the sample and the reference population. Therefore, sample weights were used as boosting factors to represent the number of units in the survey population that are accounted for by the sample unit to which the weight is assigned. An appropriate weighting scheme which includes base weights and post stratification considerations was used for the computation of survey weights. The weights were then used for purposes of estimation of study population parameters.

### 3.3. DATA COLLECTION

The data for this study was collected from both primary and secondary data sources. The secondary data was gathered from already existing reports and publications while the primary data was gathered through face-to-face interviews using a questionnaire. The interview guide consisted of both open and closed-ended questions. Open-ended and closed-ended questionnaires were designed to solicit information relating to the impact of the solar mini-grids on each stakeholder. Additionally, interviews were adopted as a method for data collection because they are cost effective and appropriate for capturing empirical data in both informal and formal settings.

# CHAPTER FOUR:

## IMPACT OF SOLAR MINI-GRIDS ON CONSUMER'S MAIN SOURCE OF ENERGY

This chapter discusses the impact of solar mini grids on consumers' main source of energy. The discussion is organized into two main sections: households and non-residential consumers (health facilities, schools, and SMEs). Each section includes a comparison between those connected to solar mini-grids and those not connected, with a focus on their main energy sources.

### 4.1 IMPACT ON HOUSEHOLDS

#### 4.1.1. Sources of Energy

This part of the report highlights the impact of solar mini-grids on the choice of energy sources for household's lighting, cooking, and heating.

##### 4.1.1. a Cooking

The research findings highlighted changes in household's cooking energy sources before and after connecting to a mini-grid. Prior to connection, 87.2% of households primarily used firewood, while 12.8% opted for charcoal. As depicted in Table 2 below, after connection to the mini-grid, firewood continued to dominate at 85.6%, with a minor increase in charcoal usage to 14.4%.

**Table 2: Households' main sources of energy for cooking**

Source of energy	Before solar mini-grid access	Solar mini-grid access
Firewood	87.2	85.6
Charcoal	12.8	14.4

The study further established that 95.8% of households in the control group reported that firewood was the main source of energy, whereas 4.2% used charcoal. The findings suggest that firewood is the main source of energy for all households regardless of access to electricity provided by the solar mini-grids. The results align with the Zambia Statistics Agency that shows that firewood accounted for the highest percentage among households for cooking purposes in the country at 50.7% (Zamstats, 2015). Solar mini-grids were traditionally designed for lighting purposes to meet the low income levels in rural areas. Electric stoves typically require a consistent and reliable supply of power, which can be challenging to maintain solely through solar generation. Generally, solar electricity generation is intermittent in nature and is affected by changes in sunlight availability which can vary throughout the day and can be inconsistent during adverse weather conditions. To ensure a continuous power source for cooking appliances, customers may need to rely on more storage appliances which might be relatively costly for rural consumers.

The continuity of traditional cooking methods underscores the need for refined strategies addressing both economic and infrastructural aspects to facilitate a more comprehensive transition towards sustainable energy practices.

### 4.1.1. b Lighting

The research findings revealed a notable shift in household lighting sources before and after access to the solar mini grid. Prior to connection, households employed a diverse range of lighting solutions, with stand-alone solar lamps with the highest proportion at 38.7%, followed by torches at 23.5%, solar home systems at 20.0%, candles at 7.7%, kerosene lamps at 7.7%, and grass fires at 2.4%.

Solar lamps were the dominate energy sources for lighting among households without access to solar mini-grids at 66.7% in the control group. However, with the introduction of the solar mini-grid, a shift occurred as 98.6% of households switched to use electricity as the main source of lighting. Meanwhile, 1.4% continued to use stand-alone solar lamps. This shift in household energy sources for lighting underscores the impact of solar mini grids in contributing to the use of sustainable energy sources.

### 4.1.1.c Heating

The research findings offered valuable insights into the energy sources used for heating by households before and after connecting to a solar mini grid. Prior to connection, 50.7% of households utilized charcoal, while 49.3% relied on firewood for heating. A similar case was observed for households without access to the solar mini-grids, of which 57.1% used charcoal and 42.9% used firewood as their energy source for heating. Interestingly, with the introduction of the solar mini-grid, a modest shift occurred, with 53.3% opting for charcoal and 44.9% still using firewood.

The continuity of traditional heating methods suggests the need for targeted interventions addressing both economic barriers and infrastructural considerations to facilitate a more comprehensive transition towards sustainable heating practices. One possible reason for the prevalence of charcoal and firewood may be the longstanding cultural and economic reliance on traditional biomass fuels for heating needs. Additionally, solar mini-grid systems are designed traditionally lighting purposes to ensure affordability.

Additionally, the none usage of the solar mini grid power for heating may be attributed to concerns about energy capacity, as heating typically demands sustained and higher energy outputs. These findings underscore the need for tailored approaches to energy solutions, considering both traditional practices and the capacity of renewable sources to meet diverse household needs.

## 4.2. IMPACT ON HEALTH FACILITIES, SCHOOLS AND SMES

### 4.2.1. Sources of Energy

Health facilities, schools and SMEs connected to solar mini grids reported a transition from traditional energy sources to solar energy. The schools and health facilities in Chitandika and Katamanda used the solar mini-grid mainly for lighting and powering electrical appliances such as computers, printers and medical cold storage facilities. Prior to the development of the mini-grid the facilities relied on solar lamps, phone torches, solar powered cold storage facilities and diesel-powered generators.

With regards to SMEs, before the introduction of solar mini-grids, diesel powered generators and stand-alone solar home systems were mainly used as energy sources. For hammer mills the source of energy was diesel powered generators, whereas grocery stores, saloons and barbershops used mainly own stand-alone solar systems. After the introduction of solar mini-grids, most hammer mills switched to solar powered motors from diesel powered motors. Similarly, the grocery stores, bars, saloons and barbershops switched to the use of the solar mini-grid for their operations.

# CHAPTER FIVE

## SOCIO-ECONOMIC IMPACT

This chapter discusses the socio-economic impact of solar mini-grids on households, schools, health facilities, and SMEs. One of the specific objectives of the study was to determine the impact of solar mini-grids on income-generating activities, income levels, and social well-being of consumers.

### 5.1. IMPACT ON HOUSEHOLDS

#### 5.1.1. Household energy expenditure

One of the ERB's functions is to regulate and review charges for licensees in the energy sector in order to safeguard the interest of consumers which also pertains to the cost of energy products and services. Therefore, the study sought to determine the impact of access to mini-grids on household's energy expenditure. Households were asked to state their energy expenditure before and after connecting to the mini-grid.

The research findings revealed that, before connecting to the mini-grid, households incurred a monthly average household energy cost of K564.44 compared to K186.86 post mini-grid connection. This reflects a reduction of 66.89% in household monthly average energy expenditure. Households reported reduced expenditure on kerosene lamps, solar lamps, torches (battery) and diesel-powered generators. Households stated that the indicated energy sources proved to be relatively more expensive because they require frequent maintenance and replacement.

The findings suggests that access to a solar mini-grid is likely to lead households to switching their energy sources for lighting compared to other energy sources for cooking and heating. This also highlights that access to solar mini-grids has the potential of offering financial relief for households. This emphasizes the transformative impact of mini grids in promoting more affordable and sustainable energy practices especially for lighting purposes.

#### 5.1.2. Income-Generating Activities

The connection to solar mini grids facilitated the emergence of new income generating activities and enhanced those already existing, both at the household and business levels. Families and businesses are engaging in previously unavailable ventures, contributing to the socio-economic well-being of households. This finding is in line with the findings of the World Bank study conducted in the Philippines which revealed that home businesses were more active and productive in areas with electricity (World Bank, 2008). This observation highlights the role of sustainable energy in fostering economic diversification and. Further, the shift from traditional income sources to new opportunities, such as small businesses powered by solar energy highlights the transformative potential of solar energy in enhancing economic activities.

Overall, the study established that among households that had been running income generating activities before the arrival of the solar mini-grid, 48.4% started new forms of income generating activities upon connection that they were unable to do before. Meanwhile, among the households that were not involved in any income generating activities and had no not undertaken any form of business before, 39.8% commenced after connecting to the mini-grid. The summary of the types of businesses that households were involved in are depicted in Table 3.

**Table 3: Types of income generating activities**

Existing Business ventures	New Business ventures
Bar	Saloon
Poultry	Selling of drinks
Sale of Food/Grocery Store	Sale of fresh food stuff
Farming and Gardening	Grocery store
Transportation business	Welding
Diesel hammer mill	Tailoring
Thrift Store	Real estate
Mechanics	Printing
Tailoring	Electric hammer mill

As depicted in Table 3, households engaged in new business ventures such as saloons, welding and printing primarily due to the arrival of the solar mini-grid. Further, business owners also switched from the use of traditional use of diesel hammer mills to electric hammer mills which improved their operations. The foregoing underscores the findings of Kirubi et al (2009), who revealed that introduction of electricity led to enhancement of the productivity of SMEs through use of electric tools and equipment and facilitated trade and commerce

With regards to business owners, the study also revealed that 44.1% of already existing businesses were positively impacted by the connection to the mini grid compared to 5.7% that reported being negatively affected. For example, existing bars and grocery stores were able to work during the night increasing their operating hours. Further, specifically to bars, they introduced music and cold beers. Meanwhile, 50.2% indicated that the business remained the same. This was attributed to the nature of the business that did not require the use of electricity such as farming.

### 5.1.3. Income Levels

The study found that access to a solar mini-grid had a positive impact on the average household income. Specifically, households reported that monthly income averaged K1,693.15 before connecting to the mini-grid. However, the average monthly income increased to K2,417.82 for households that connected to the mini-grid. This reported increase in household income is in accordance with Khandker et al. (2013) and Osanyinlusi's et al. (2017) findings of a significant positive impact of rural electrification on household income.

Households attributed the increase in income to engaging in income generating activities. Among households that had existing income generating activities, the connection to the mini-grid enabled them to introduce new products and services that contributed to the increased income. Furthermore, the reported increase in income was due to increased savings on energy expenditure.

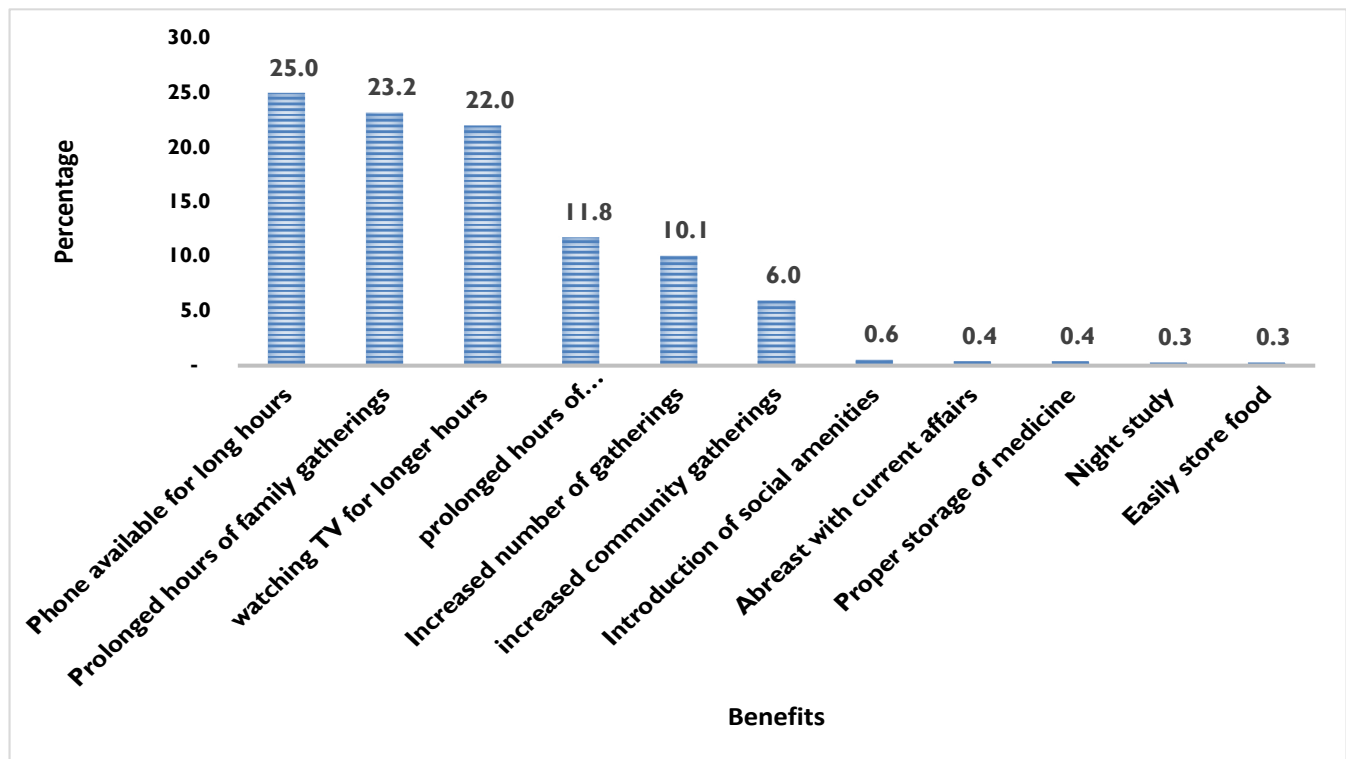
It was observed that households without access to solar mini-grids had a lower average monthly income of K1,790.00 compared to K2,417.82 for those with access. The observed lower monthly average household income level could be attributed to limited business opportunities and higher operating costs. Further, the operating hours for income generating activities is lower due to the lack of lighting and so their income levels are adversely affected. In addition, most businesses were limited in the types of services and products they offer due to the lack of reliable electricity, thus reducing their income further.

### 5.1.4. Social Well-being

The adoption of solar mini grids can lead to notable improvements in the social well-being of households. Increased access to electricity positively influences health, safety and overall quality of life (Irwin et al, 2019). The study sought to establish the impact of solar mini-grids on the social well-being of households.

The findings showed that with regards to social wellbeing, 25% of households reported increased availability of phone hours. This was followed by 23.2% reported prolonged hours of family gatherings. Additionally, 22% stated that they experienced an increase in the number of hours in watching TV. The least responses were night study and easy storage of food at 0.3%. This is depicted in figure 1.

**Figure 1: Percentage distribution of benefits brought by connection to solar mini grid**



Additionally, the ability to charge devices and the acquisition of new devices positively impacted educational outcomes.

### 5.2. IMPACT ON HEALTH FACILITIES, SCHOOLS, AND SMES

The introduction and connection to the solar mini-grid positively impacted schools in a diverse range of ways. Two of the four schools interviewed reported having introduced night study sessions for examination classes primarily because of the lighting from the solar mini-grid. This finding resonates with Barnes (2004), who, in his study done in Costa Rica, found that rural electrification led to the increase of night classes. Additionally, Gustawson's (2007) study done in Zambia on the educational benefits from solar technology, concurs that access to solar mini-grid is associated with more study time for school going children.

Some schools stated that connecting to the solar mini-grid enhanced their lesson delivery with the introduction of teaching aids such as projectors and the ability by teachers to prepare lesson plans in the night. Further, other schools stated that connection to the solar mini-grids enabled them to

introduce new subjects such as computer lessons. This shows the possible role that electrification plays in improving computer literacy in rural areas.

With regards to Health facilities, connection to the mini-grid improved their service delivery. This was revealed by the findings that showed that health facilities were able to use smart care<sup>6</sup> to promptly attend to patients and easily store their information. Further, health facilities were able to store vaccines and medicines for longer periods in cold storages leading to a prolonged availability. Connection to the mini-grid also enabled health facility workers to be able to easily work at night and attend to patients that came during those hours. These outcomes indicate the positive impact of solar energy on healthcare services.

As for SMEs, the study also revealed that 45% of businesses were operating before the arrival of the solar mini-grid. Meanwhile, 55% commenced operations after connecting to the solar mini-grid. Overall, 75% stated that access to the mini-grid had positively influenced the financial position of the business. Additionally, 90% reported that access to the solar mini-grid helped their businesses operate efficiently. On the other hand, 52% stated that connecting to the solar mini-grid did not lead to the reduction of their energy expenditure.

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<sup>6</sup> A fully integrated electronic health records system and clinical management information system at the facility and district (management/admin) level.

# CHAPTER SIX: CONSUMER PERCEPTIONS OF SOLAR MINI-GRID SERVICES

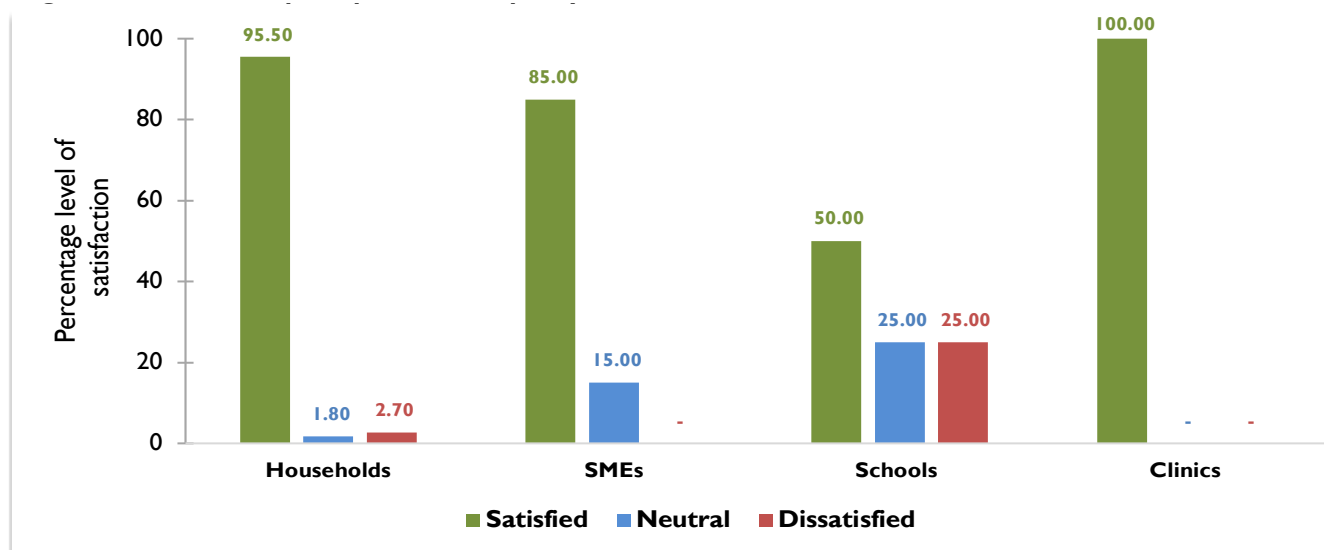
This chapter provides an in-depth analysis of the research findings on assessing the consumer perceptions on the quality and reliability of electricity provided by solar mini-grids. This is in line with the study objective of exploring consumers' perceptions on the quality and reliability of the service provided by a solar mini-grid.

## 6.1. QUALITY OF SERVICE

The ERB assesses the quality of service of solar mini-grids through monitoring of frequency and duration of power outages. Additionally, the ERB is also mandated to resolve consumer disputes between the consumer and the licensee. In line with this mandate, the study assessed consumers' perceptions of the quality of service provided by the solar mini-grids. In this study, the overall quality of service was measured using two metrics, i.e. reliability of service and complaints handling procedure.

The study found that 95.5% of the household connected to the solar mini-grids were satisfied with the quality of service, 1.8% were neutral and 2.7% were not satisfied. As for SMEs, 85% were satisfied with the quality of service, whereas 15% were neutral and none were dissatisfied. Additionally, 50% of the Schools were satisfied with the quality of service of the solar mini-grid whereas 25% were neutral and the other 25% were dissatisfied. Furthermore, all the health facilities were satisfied with the quality of service provided by the solar mini-grids. Figure 2 presents the satisfaction levels by customer category.

**Figure 2: Consumer's perception about quality of service**



The SMEs, Schools and Health facilities were asked to comment on their perception of reliability of the services provided by the mini-grid. A higher proportion of 66.7% of Schools and Health facilities indicated being satisfied with the services of the solar mini-grids. Meanwhile, 16.6% were dissatisfied. The summary of these results is presented in Table 4.

**Table 4: Percentage distribution of satisfaction level with reliability of services by Health facilities and Schools**

Level of satisfaction	Percentage
Satisfied	66.7%
Neutral	16.7%
Dissatisfied	16.6%

With regards the reliability of services provided to SMEs by solar mini grids, 88.9% of participants reported satisfaction. Notably, none of the respondents reported any dissatisfaction, whereas 11.1% were neutral. Table 5 below shows the percentage distribution of SMEs' rating of the reliability of services provided by mini grids.

**Table 5: Percentage distribution of satisfaction level with reliability of services by SMEs**

Level of satisfaction	Percentage
Satisfied	88.9
Neutral	11.1
Dissatisfied	0.0

### 6.1.1. Power outages

Reliability of service was measured using the time taken to restore service once an interruption occurs. The survey revealed that a higher percentage at 79.4% acknowledged encountering interruptions, while 20.6% reported an absence of power outages.

As seen in Table 6, the majority of the households that acknowledged having interruptions reported that it took more than 48 hours for power to be restored after a power outage. The second most notable time it took to restore power was the three to seven hours range. Table 6 shows the distribution of reported power restoration times.

**Table 6: Percentage distribution of reported power restoration times**

Duration (hr)	Distribution (%)
$hr < 3$	14.06%
$3 \leq hr \leq 7$	29.69%
$7 < hr \leq 24$	6.25%
$7 < hr \leq 48$	6.25%
$hr > 48$	37.50%
Not sure	6.25%

### 6.1.2. Complaints handling

The assessment of the customer complaints handling process of service of the solar mini-grid was focused on customer perceptions of how easy it is to lodge a complaint and the resolution rate<sup>7</sup>.

The findings showed that 52.9% of households reported lodging complaints with their mini grid operator while 47.1% did not. Of those that lodged in a complaint, 97.4% found the process easy and 2.6% found it to be difficult. With regards to complaints resolution rates, 10.6% of the complaints were resolved within a few hours, 23.8% within a day, 27.9% within a week and 37.6% took more than a week. Additionally, 41% reported being dissatisfied with the complaints handling process, whereas 24.7% were neutral and only 34.3% were satisfied.

Overall, the results show that all three customer categories were satisfied with the services of the solar mini-grid. In addition, 96% of the households plan to continue accessing the services of the mini-grid due to the factors listed in Table 6.

**Table 7: Reasons for wanting continued access to the solar mini-grid**

Reason	%
Cost efficient	32.0
Only if tariff is reduced	2.9
Helpful with charging phones	4.2
Helpful with lighting	11.5
Helpful with business	9.0
Brings Joy	2.7
Plans to start a business	8.1
Income has increased	3.9
Improved life	25.7
<b>Total</b>	<b>100.0</b>

## 6.2 AREAS OF IMPROVEMENT

House holds were asked to state suggestions on how the solar mini grid service can be improved. The highest proportion of the respondents at 65.0% indicated that the solar mini grid operators should increase the load capacity of the grid so that they are able to use more appliances such as cooking stoves, pressing irons among the appliances that they cannot use. This is not surprising considering traditionally, solar mini-grids systems have been designed as a major source of energy for lighting purposes. Further, 17.1% and 10.1% of the households proposed that the mini grid operator should consider reducing the electricity tariff and improve on maintenance works so that occurrence of outages is significantly reduced.

# CHAPTER SEVEN

## CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusion based on the objectives and findings and provides recommendations of the study.

### **7.1. THE SOCIO-ECONOMIC IMPACT OF SOLAR MINI-GRIDS ON END-USERS, IN TERMS OF CHANGES IN CONSUMERS' INCOME, ENERGY EXPENDITURE, AND ENTREPRENEURIAL ACTIVITIES BROUGHT ABOUT BY A SOLAR MINI-GRID.**

The study has demonstrated that access to a solar mini-grid has positive impact on the average monthly household income. Specifically, the study found that households monthly average income increased by 42.8% from K1,693.15 to K2,417.82 after connecting to the solar mini-grid. Households attributed the increase in income to engaging in economic generating activities. Additionally, among households that had existing income generating activities, the connection to the mini-grid enabled them to introduce new products and services and increase their operating hours.

The findings also revealed that a reduction in households' monthly energy expenditure was associated with access to solar-mini grids. The monthly average energy expenditure reduced to K186.86 compared to K564.44 before connecting to the mini-grid reflecting 66.9% reduction. This reduction was mainly on account of reduced expenditure on lighting as households switched from the use of kerosene lamps, solar lamps, torches (battery) and diesel-powered generators to solar mini-grid. Consequently, households experienced financial relief from the energy savings due to the switch.

On the question to determine the changes in entrepreneurial activities brought about by the mini-grid, the study established that 48.4% of households started new income generating activities that they were unable to undertake before. Similarly, 39.8% of household engaged in income generating activities after connecting to the mini-grid. On the other hand, the findings showed that the number of SMEs increased by 55% after connecting to the solar mini-grid.

### **7.2. CONSUMERS' PERCEPTIONS ON THE QUALITY AND RELIABILITY OF THE SERVICE PROVIDED BY A SOLAR MINI-GRID.**

The second objective of this study was to explore consumers' perceptions on the quality and reliability of the service provided by solar mini-grids. The study found that 95.5% of the household connected to the solar mini-grids were satisfied with the quality of service, 1.8% were neutral and 2.7% were not satisfied. As for SMEs, 85% were satisfied with the quality of service whereas 15% were neutral and none were dissatisfied. Additionally, 50% of the Schools were satisfied with the quality of service of the solar mini-grid whereas 25% were neutral and the other 25% were dissatisfied. All the health facilities were satisfied with the quality of service provided by the solar mini-grids.

Despite higher percentages of consumers that expressed satisfaction with the services provided, 65% of the households were of the view that the solar mini grid operators should increase the load capacity of the grid so that they are able to use more appliances such as cooking stoves and pressing irons. Furthermore, 15.8% of the households proposed that solar mini grid operators should consider reducing the electricity tariffs which were considered high. The findings suggest that the number of households was lower than the 50% of customers required to petition the ERB to undertake a tariff review as per existing mini-grid regulatory framework for category one. The ERB has the mandate to review and adjust the tariff if it is deemed that the developer is over recovering on approved revenue requirements. Additionally, 7.9% of the households were of the view that the reconnection time after a client has paid should be reduced.

Furthermore, seeing that 41% of the households reported being dissatisfied with the complaints handling process, households proposed that the mini-grid operators should improve their customer complaints handling procedure as they take long to respond to consumer complaints.

### **7.3. THE IMPACT OF A SOLAR MINI-GRID ON THE LIFESTYLE (SOCIAL WELLBEING) OF END-USERS.**

The access to solar mini-grid had positive impact on social wellbeing of end users, 25% of the households reported increased availability of phone hours. Additionally, households also expressed longer family gatherings at 23.2%. Furthermore, the access to mini-grids was also associated with increased number of hours of watching TV at 22%. Meanwhile, the least response was recorded at 0.3% for night study and easy storage of food.

### **7.4. CHANGES IN CONSUMERS' SOURCES OF ENERGY**

The research findings showed that the solar mini-grid had an impact on the shift towards the use of electricity as a main source of energy for lighting, while there was no significant change in relation to the other uses (i.e. cooking and heating). Firewood remained the main energy source for cooking with the highest percentage usage at 85.6% among households with mini-grid connection, declining marginally by 1.6 percentage points, from 87.2% prior to the arrival of the mini-grid. Similarly, households without access to solar mini-grid indicated that, they used firewood for cooking at 95.8% as a main source. Meanwhile, the usage of charcoal was second at 14.4% reflecting a 1.6% percentage points among households that migrated to the use of solar mini-grid.

The research findings also showed that a higher percentage of households with mini-grid connection at 53.3% used charcoal as the main source of energy for heating compared to 50.7% before the mini-grid arrival. This was followed by the use of firewood at 49.3% increasing from 44.9% before solar mini-grid connection. A similar case was observed for households without access to the solar mini-grids, of which 57.1% used charcoal, while 42.9% used firewood as their energy source for heating.

Cooking and heating typically demand sustained and higher energy outputs that a solar mini-grid is unable to meet. However, there is a lack of matching demand and load during the planning phases of solar mini-grids. This leads to installing a solar mini-grid that is too big or too small to meet the demand requirements of the area. Hence, this makes some mini-grid projects non-financially viable. This was echoed by respondents who stressed the need for increased capacity to support the use of essential appliances like electric stoves and pressing irons.

A notable difference in households' sources of energy was recorded under lighting. The findings revealed that 98.6% of households relied on power from the solar mini-grid for lighting, while 1.4% continued to use alternative energy sources. Prior to the arrival of the solar mini-grid, the use of stand-alone solar lamps was the most prevalent at 38.7%, followed by torches at 23.5%, solar home systems at 20.0%, candles at 7.7%, kerosene lamps at 7.7%, and grass fires at 2.4%. However, among households without access to a solar mini-grid, the use of solar lamps continued to dominate as the energy source for lighting at 66.7%. The findings suggest that a solar mini-grid is likely to have an impact as an energy source for lighting compared to the other two uses (cooking and heating).

The connection to the mini-grid for schools and health facilities enabled the use of electricity for lighting and powering electrical appliances such as computers, printers and medical cold storage facilities. Prior to the development of the solar mini-grid the facilities relied on solar lamps, phone torches, standalone solar powered cold storage facilities and diesel-powered generators. Additionally,

among SMEs, most businesses mainly relied on diesel powered generators and stand-alone solar systems. The introduction of solar mini-grids witnessed a shift towards the use of electricity for lighting purposes and the other electrical appliances.

## **7.5. RECOMMENDATIONS**

The findings have broader regulatory and policy implications on solar mini-grids developments in relation to understanding the socio-economic impact on end-users. The study makes the following recommendations:

1. The government should consider increasing financial support to the Rural Electrification Authority (REA) to enable the roll out of more solar mini grids in rural areas.
2. The government should consider offering more incentives for the private sector to set-up more solar mini-grids in remote areas which do not have access to the national grid.
3. The ERB should undertake awareness and sensitization programmes for solar mini-grid consumers on their right to escalate their complaints when they are not satisfied with the complaints handling procedure of the mini-grid operator.
4. The ERB should conduct a future study with a wide scope to include different technologies to ensure an in-depth understanding of the socio-economic impact of mini-grids in general on end-users across the country.

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