UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

IMPACT OF PUBLIC SOLAR PV ELECTRIFICATION IN RURAL MICRO-ENTERPRISES. (A CASE STUDY IN TWIFO-HEMAN AND ASSIN NORTH DISTRICT IN THE CENTRAL REGION)

KINGSLEY ANTWI

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(7131200023)

A Dissertation in the Department of DESIGN AND TECHNOLOGY EDUCATION, Faculty of TECHNICAL AND VOCATIONAL EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba Kumasi, in partial fulfilment of the requirement for award of the Master of Technology (Electrical/Electronic) degree

AUGUST, 2015

DECLERATION

STUDENT'S DECLERATION

I, **Antwi Kingsley**, declare that this Thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole for another degree elsewhere.

SIGNATURE: ……………………………………….…………

DATE: ………………………………………………….………

SUPERVISOR'S DECLERATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Thesis/Dissertation/Project as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: **DR. MARTIN AMOAH**

SIGNATURE: ……………………………………….…………

DATE: ………………………………………………….………

ABSTRACT

The development of micro-enterprises in rural off grid areas in Ghana is linked with the increase in access and use of solar PV electricity services, leading to changes in micro-enterprises, and changes in livelihood characteristics of entrepreneurs, employees and community members in areas where these enterprises located. The thesis was to evaluate the impact public of solar PV in micro-enterprises in off grid rural areas. Convinience sampling techniques was used for this study, 60 solar PV powered shop owners were sampled in Twifo Heman Community. The study was to examine the economic benefits and identify challenges; financial, technical and maintenance of solar PV systems in rural electrification on micro-enterprises and also to evaluate job performance after and before micro-enterprises where connected to solar PV installations. The main aim of this research was to explore linkages between increased access to solar PV electricity services and micro-enterprise development in off grid rural areas in Ghana. This project investigated changes in both micro-enterprises and livelihood of people involved in enterprises after uptake of solar electricity services for operation. Livelihood context was used to contribute to understanding of the changes happening in micro-enterprises both within and between each other after up taking of solar electricity services. The findings of the study shows that the growth rate of micro-enterprises were noticeably higher in areas with electricity services, but the proportion was low compared to micro-enterprises growth rate and time of solar electricity introduction.

DEDICATION

This work is dedicated to my wife and beloved children. I am grateful for your love, patience, financial sacrifices, prayers and everything.

ACKNOWLEDGEMENT

I am grateful to the Almighty God for giving me the strength to complete this work successfully. I also owe a debt of gratitude to all those who in spite of their busy schedule devoted their time to guide me to complete this work. To all my lecturers at the University of Education, Winneba, I wish to express my profound gratitude for their unconditional encouragement, guidance and support throughout the programme.

I say a special thank you from my deepest heart to my supervisor, Dr. Martin Amoah for his motivation, and direction.

Finally, I would like to thank the many authors and publishers whose works have guided me to better understand the subject area of the study. Thank you all.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Energy is the key which unlocks all other resources and will continue to be the answer to human"s physical prosperity by fuelling the modern world. The per capital availability of energy to humans directly or indirectly determines the materials standard of living (Arvidson and Gustafsson, 2002) This energy serves as the backbone to all productions in Ghana, including micro and small scale industries. Despite their significance in Ghana"s industrialization, the generating stations have not only been characterized by their inability to supply enough electricity to meet a middle income economic status (evident in electricity backlog of 3,615 megawatts in 2009 estimated to decrease slightly to 2,135 megawatts by 2012) but also unreliability due to unfavorable weather conditions. For instance, in 2007, due to the low amount of rainfall, the level of the water in the Akosombo reservoir reduced to an unprecedented level of 240.00 feet, about 15.8 per cent lower than the minimum water level required to render the turbines effective and efficient (Abavana, 2004).

However, global trends indicate that, the world"s climate is ever changing in the face of global warming which is an indication that the rainfall pattern is forever going to be erratic (Acheampong, 2003; DFID, 2001). Thus, any energy source that depends on the rainfall regime is not sustainable (DFID, 2000). This debates the reliability and sustainability of the Bui Dam Project. It is important also to state that, the rivers (Black Volta and River Volta) on which the two dams (Akosombo and Kpong) have been established are international ones with geopolitical implications. Ghana"s geographical location in the tropics, solar radiation is available almost throughout the year across the ten regions. The country receives 4.0 – 6.5 kwh/m^2 day of solar radiation and sunshine duration of about 1800 – 3000 h per year.

Renewable resources within Ghana are wind, biomass, solar, hydro, and geothermal. Most regions in Ghana are endowed with renewable resources. The advantages are naturally ubiquitous, accessible in large quantities, progressively low cost, non-vulnerable to supply or price fluctuations and compatible with the global consensus to increase low-carbon emissions. Solar PV can be viewed as the contender in rural electrification to improve the quality of life of rural small scale and micro enterprises in developing countries (Addo, 2007).

The quality of life is expected to be fulfilled in better education, health delivery, access to information, indoor lighting among others. Again, significant impacts of solar PV systems in better quality of lighting, car batteries do not have to be transported, and indoor smoke and fire hazards from usage of kerosene lanterns in rooms are reduced. (Possorski, 1996; Obeng, 2008). Furthermore, solar PV electrification in off-grid rural communities has direct effect on households" wellbeing and enterprise income (Cabraal 1996, fishbein 2003 Martinot, 2002, Possorski, 1996).

1.2 Statement of the Problem

Electricity is essential to meet the basic needs of a developing economy. However, Ghana has a history of power cuts, and an unreliable grid infrastructure capacity (Gyasi, 2008). Heavy pollution and expensive diesel generators are currently being used to supply electricity when the grid fails. A lot of rural people who still lack access to electricity find it difficult to power their small-scale enterprises. This situation is even getting worse because of high population growth in these rural communities and economic growth will demand more energy in the near future. However, over two decades, the electricity sector of the country has experienced inadequate supply of power as a result of low inflows into the reservoirs of the Akosombo hydroelectric dam and inadequate alternative generation capacity (Energy Commission, 2004).

Though government policy is to achieve universal access to electricity by the year 2020, grid access level remains very low in the rural areas. Out of the 3,701,241 households in Ghana, only 24.9 percent of the rural households have access to grid-electricity compared to 81 percent of the urban households (Ghana Statistical Service, 2007). The consequence is that, nearly 83 percent in the year 2000 and 75 percent of rural households depended on kerosene lantens as their main source of lightening in the years 2003-2014 (Ghana Statistical Services, 2007). An important step in the country"s electrification process is the integration of solar photovoltaic (PV) systems into the rural electrification programme to widen electricity access to rural households in small-scale enterprises for poverty reduction (World Bank, 2003).

There are however few researches into the impact of solar PV in small-scale rural enterprises for poverty reduction in Ghana. Additionally, the cost recovery approach to the provision of rural electrification and its marginal returns in terms of revenue, based on its social benefits has slowed down the extension of electricity to rural areas in developing countries

(Dadzie, 2008). Despite its importance, contributions and potential of Micro-enterprises in the Ghanaian economy, there are several factors that hinder their establishment, growth, decline and closure. One of the factors, which may contribute to these problems is lack of available and reliable electricity services no the possibility of utilizing modern electrical appliances, welding kits, and machinery which may pave the way to small and cottage industries. There is also no convenient lighting in businesses such as bars and retail shops, which reduces the number of customers. The lack of linkages between uses and impact of electricity services and micro enterprises establishment, survival, expansion, growth, decline and closure in rural areas in developing countries in general makes this study a necessity.

This is as a result of absence of data on the benefits of rural electrification with regards to small-scale enterprises development. This thesis aims at identifying the barriers that hinder livelihood improvement in the use of solar PV in small and medium scale enterprises in Twifo- Heman and Assin-North Districts in the Central Region. It is on this background that there ought to be enough information to determine the contribution of solar PV rural electrification development through growth of small and medium scale enterprises in Ghana.

1.3. Purpose of the Study

The purpose of the study is to assess the impact of solar PV in rural micro-enterprises on energy-poverty status of households, and to determine the factors that hinder energy-poverty improvement in off-grid rural households to support socio-economic development. To achieve these, the following specific objectives are outlined:

I. To evaluate the technical challenges of solar PV in rural enterprises
II. To identify the social impact of solar PV in rural communities
III. To examine the economic benefits of solar PV in rural micro-enterprise.
IV. To evaluate job performance before installation of solar PV.

1.4 Research Questions

In order to achieve a more reliable data for the study, the following research questions are prepared as a guide in the course of the research work.

I. What are the technical challenges of solar PV in rural micro-enterprises?
II. What are the economic benefits of solar PV in rural micro-enterprises?
III. What are the social contributions of solar PV in rural communities?
IV. What are the performances of micro-enterprises before and after PV installation?

1.5 Delimitation

The study is delimited to Twifo-Heman rural and Assin-North Districts in the Central Region who reside behind the Pra River. The study will also focus on the use of solar PV electricity in the livelihood impact on small scale enterprise in the rural communities.

1.6 Organization of the Study

The study is organized into five chapters; chapter one provides the general introduction to the study. Chapter two reviews some of the available literature works whereas chapter three shows the methodology (procedures) in conducting the research. Chapter four deals with the results and discussions of the study whilst chapter five indicate the summary of the findings, conclusions and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter reviews some of the literature works related to the study. It is globally accepted that electrification does not only stimulate economic growth at a broader level but also can enhance quality of life at the household level. It is generally agreed that the immediate benefit of solar photovoltaic (PV) electrification comes through improved lighting. All the same, in off-grid rural communities, the use of solar PV for powering electronic devices such as radio and television can significantly contribute to increase access to information and entertainment at the household level and this is reported in several studies (Wamukonya & Davies, 2001; Obeng & Evers, 2009). But, there appears to be a lack of data on the quantitative impacts of solar PV in rural micro-enterprises on the livelihood of rural communities.

2.1 Role of Rural Micro-Enterprises in National Development

The examination of the role that Micro Scale, Small and Medium Industries (MSMIs) play in national development is done by first defining MSMIs. The definitions gave prominence to definitions used by authorities in Ghana. This is based on the differences that exist among countries‟ definitions of MSMIs. Barnet (2000) argues that there is no universally accepted definition for the term micro and small scale industries (MSMIs). Definitions that emphasizes the size of firms (number of employees, turnover, profitability, etc.) when applied to a sector could lead to all firms being classified as small, while the same size criterion when applied to a different sector could lead to a different result (James, 2008). Thus, firms differ in their levels of capitalization, sales and employment. This has challenged any attempts at deriving a uniform definition for MSMIs. Despite this challenge, attempts have been made to distinguish between small and medium scale industries.

Grosh and Somolekae (2006) reveal that the first attempt to overcome the definition challenge was by the Bolton Committee in 1971. The Bolton Committee used different criteria (number of employees, assets and turnover) to classify industries as small, medium and large scale industries (SMIs). The attempt did not provide a definition for micro scale industries. Thus, the definitions of micro scale enterprises were given a consideration in the latter years (1990s).

Under the manufacturing, construction and mining and quarrying sub-sectors, the number of employees was used as the indicator for distinguishing small scale enterprises from medium scale and large scale enterprises. Whilst manufacturing firms that employ less than 200 workers are considered small, enterprises in the construction and mining sectors are classified as small if they employ less than 25 workers.

Due to these differences, the National Board for Small Scale Industries (NBSSI) in Ghana uses both fixed asset and number of employees to define SMIs. The Board defines a small scale industry as one with not more than 9 workers with plant and machinery value (excluding land, buildings and vehicles) of not exceeding US$ 10,000. MSMIs play diverse roles in the development of national economies (Grosh and Somolekae, 2006). UNDP (200), point out that MSMIs have been recognized as the engines through which the growth objectives of developing countries can be achieved. They are potential sources of employment and income generation in many developing countries. Gibson and Kelly (2010), however, indicated that there is a considerable disagreement within development policy circles against the notion that MSMIs provide efficient jobs for national development. This contrasting argument considers the role of the overall business environment in any given country to national development and not the MSMIs in isolation. The critics further maintain that MSMIs are characterized by high degrees of inefficiencies and low productivity and thus their contribution to national development has been marginal.

They point out that the MSMIs sub-sector is the highest contributor of employment in many countries employing more than 70 per cent of the labour force in most Less Developed Countries (LDCs). MSMIs employ about 60 per cent of the workforce in Ghana, 55 per cent of the workforce in Canada, 70 per cent in the European Union and at least, 70 per cent of private sector workforce in South Korea. In 2006, MSMIs employed around 4.1 million people (42 per cent of total labour force) in Australia.

The point that MSMIs" absorb the labour force in employment made by several authors, is further reaffirmed in an article dubbed the "Export Strategy for the Romanian Light Industries Sector (Textiles; Clothing and Leather)" published about the Romanian economy. The article claimed that the light industrial sector was accountable for 5.5 per cent of GDP, 20.4 per cent of total employment, 9.9 per cent of the industrial production volume and 34 per cent of exports in the year 2004 (ILO, 2002). The more MSMIs that a country has, the higher the sources and rates of employment it is likely to enjoy in the near future.

The development of large corporations in developing countries is highly dependent on the presence of MSMIs. Rostow explains this in "the Process of Economic Growth" (1952 cited in Borchers, Mark and Hofmeyr, 1997) and "Stages of Economic Growth" (1960 cited in Etcheverry, 2003). He argues that the dynamics of industries usually starts with a takeoff (small or medium scale but efficient) and then moves to technological maturity, usually associated with high mass consumption.

2.2 Industrial Energy use in Ghana

The nation Ghana has a fairly large and vibrate industrial sector which contributes about 24 % of the country"s Gross Domestic Production (Wikipedia, 2011); these industries are made up of mining, lumbering, manufacturing, aluminum smelting, food processing, cement and small commercial ship building(DFID, 2000). This sector mainly produces and provides services not only to the local Ghanaian economy but also to the West Africa sub-region at large; and some semi-processed products are exported internationally to generate capital.

The major energy sources used for industrial purposes are wood fuels, electricity and petroleum products (diesel, gasoline and residual fuel oil) (see figure below). Industrial energy in this sector is used by subsectors like mining, utilities, manufacturing, construction and The Volta Aluminum Company (VALCO) (an aluminum smelting company). According to the Ghana Statistical Service, the manufacturing sector of Ghana is subdivided into formal and informal manufacturing companies; formal manufacturing companies consist of large industries like smelting companies, cement factories, textile factories and many more. The informal group comprises of small scale manufacturing businesses like carpentry and craft businesses. Since 2000, the manufacturing subsector has been the dominant energy consumer, accounting for about 74% of industrial energy share, followed by Mining and quarrying (9-10%) Energy Commission, Ghana, 2014). Both the utilities and construction subsectors consume approximately about 2-3 % of the annual industrial energy use (ibid). The industrial sector is the largest consumer of electricity in Ghana, also electricity represent the largest form of energy used in the industrial sector (excluding informal manufacturing sector) it accounted for about 55-56% of the total industrial energy share during the period of 2000-2004. Most formal manufacturing companies (high-energy intensive) in Ghana are highly reliant on electricity; as such, hikes in electricity prices and unreliable supply of electricity affects the productivity of these industries. . Diesel is mainly used to power diesel engines in industrial outfits, whiles the residual oil is mainly used for heating purposes. Some industrial outfits in Ghana use gasoline to power their standby electricity generator when there is power outage. The industrial sector is the second largest consumer of wood fuel in Ghana and it accounts for about 25% of total wood fuel (Energy Commission Ghana, 2014). Wood fuel is the most used fuel in the informal manufacturing subsector. The use of wood fuel in this sector is mainly for firing boilers and other heating processes. In the view of (Katyega, 2003), one of the pre-requisites for the development of the manufacturing industries is affordable and abundant supply of energy, particularly, electricity for driving the industries machinery.

This argument is underpinned by the fact that manufacturing industries are the major users of any country‟s stock of energy. He claimed that it is due to the significant role energy plays in the development of manufacturing industries that manufacturers always stress on the provision of affordable and reliable electricity for production. Thus, the availability and reliability of energy for industries in a country determines the level of development of the country in question. This is evident in the high quantity of energy consumed by the developed countries relative to that of the developing world (Smith, 2005). Thus, the developed countries are developed mainly because they consume higher amount of energy (Kjellstrom, 1992).

Similarly, it is reveal that the manufacturing sector of the United States‟ (US‟s) economy consumes about 650 billion kWh per year (30 per cent) of the US total electricity production. Due to the manufacturing sector‟s importance in national development and its large share of energy, mainly, electricity consumption, the proliferation of industries has an important implication for energy sector planning. Thus, the stock of energy in a country needs to be expanded to meet the growing demands of electricity for manufacturing industries for sustained growth of national economies.

In contributing to the significance of energy (electricity) to the development of the manufacturing sector, the UNDP (2000) points out that the first Government of Ghana sought to build the Akosombo dam to supply electricity to drive her import substitution industrialisation policy. Additionally, the Centre for Policy Analysis - CEPA and the MoFEP reveal that due to the power rationing exercise in Ghana, the manufacturing sector‟s contribution to GDP slacked from 9.5 per cent in 2006 to 7.4 per cent in 2008. Unreliable electricity supply in Ghana is subsequently ranked first among 13 problems identified to affect the manufacturing sector (UNDP, 2000).

Similarly, Luvanga, (1997), pointed out that the rising cost of electricity in the US has affected the operations of industries mainly the MSMIs because they did not have the capacity to invest in production methods that are energy efficient or did not create alternative methods of production (methods that do not rely heavily on energy use). Velázquez further argued that the rising cost of electricity is one of the reasons for inflation in the US.

From the above, it was concluded that energy was one of the factors that determined manufacturing industries‟ cost of production which in turn determined the extent of inflationary pressures in an economy. This accentuates the claim by UNDP (2000) that energy is the key which unlocks all other resources, and will continue to be the answer to human‟s physical prosperity by fuelling the modern world. GEC (200) also asserts that the aspirations of developing countries for higher living standards can only be satisfied through sustained development of their electric power markets as part of their basic infrastructure. Thus, the role of energy in national development is indispensable. Dadzie, (2008) sums up the link between energy and the development of MSMIs by remarking that "most economic activity would be impossible without energy, even the small-scale village and household enterprises in developing countries that are the main source of income for the poor in those countries".

2.3 Growth and Decline of Micro-enterprises

In Tanzania, the most important factors inhibiting growth and decline in the micro enterprises sector are not well known. Based upon research conducted in Africa on micro-enterprises, it is possible to identify specific micro-enterprises that are most likely to either survive or close. The findings show that those micro-enterprises that had added employees since their start-up were more likely to survive than those that had retained the same number of employees. A key finding was that the majority of micro-enterprises do not grow at all, as measured by indicators of employment. Among the estimated 20 percent that do grow, most grow only by a little by adding workers not more than ten people.

The above argument is supported by Grosh and Somolekae (1996) who cite other sources to the same effect: "Most of enterprises which begin on a micro scale remain that way indefinitely and only a few medium-scale enterprises begin as micro-enterprises. In a sample of 237 firms in Botswana, only 2.5% had at any stage grown beyond 10 employees, though 19% of the firms were over 10 years old. Gilbertson et. al., (1993) traced 116 firms in Nigeria after 30 years, only two firms of the 21, which originally had fewer than 10 employees had graduated into a larger category 30 years later. Furthermore, out of 116 firms, 13 employed over 50 employees, but only one of those had begun as a micro-enterprises. Mead and Liedholm (1998) found in Botswana, Kenya, Malawi, Swaziland and Zimbabwe that most firms which started with one to four workers never expanded; and less than 1% grew into the category of over 10 employees". A number of reasons have been given as barriers which block growth graduations for most micro-enterprises. Examples include lack of access to capital, lack of education and lack of market and technology.

2.4 Impact of Electricity Services on Micro-enterprises

There are varieties of micro-enterprises in the rural areas of Tanzania. These MEs can be distinguished according to the nature of activities and type of energy services they use for production or performing their services. Micro-enterprises such as brick burning, local beer brewing, ceramic firing, salt drying, fish drying and smoking, and charcoal production depend on biomass fuels as a source of process heat. Other micro-enterprises like retail shops, salons, restaurants and bars, wood processing, welding, depend on electricity services for lighting, refrigeration, entertaining customers (playing Radio, Music systems and Television), cooking, baking, shaft power, grain grinding and oil processing (Sawe, 2004).

In Tanzania, the electricity consumers identified in four districts located in rural areas (Same, Sumbawanga, Njombe, and Babati) can be classified as light commercial and light industrial. However, most light commercial industries do not really depend on electricity for their operation. The light industries like welding workshops and garages use electricity for running electric motors and for lighting. The average electricity consumption for these small industries is higher, ranging between 394 to 924 per month while for the residential and light commercial consumers, the range is between 100 and 200 per month (Kjellstrom, et al., 1992). A study undertaken in Namibia about impact of rural electrification on social–economic development shows that electricity services do not seem to have had a significant impact on growth of income generating activities (Wamukonya & Davis, 2001). The findings from the same study show that the share of households with home-based income generating activities was highest among unelectrified households. Furthermore, few home- based enterprises use electricity for income generating activities, and when they do, mainly make use of electricity only for lighting. None of the businesses using electricity started after rural electrification and hence electricity service could not have been the driving factor behind the establishment of the new micro-enterprise (Wamukonya & Devis, 2001).

2.5 Rural Electricity in Ghana

Due to the significant contribution of electricity to national development, this section of the study reviews the efforts that have been made in Ghana to provide adequate and affordable electricity for the development of industries. Since electricity is observed as a major tool for national development, vigorous efforts have been made to ensure that industries have access to reliable and affordable electricity in Ghana (UNDP, 2000). Electricity in Ghana has thus gone through a period of evolution since the colonial era to present day Ghana. According to the Institute of Statistical, Social and Economic Research (ISSER) (2005), electricity provision in Ghana has evolved through three stages identified as the "before Akosombo," "the hydro-years and the thermal complementation".

The „before Akosombo" is the period preceding the first hydro-electric power project in Ghana (before 1966). During that time, diesel generators were used to generate power for industrial, health and private consumption purposes (ISSER, 2005: p.16). The first public electricity supply generated in Sekondi in the Western Region, was mainly for railway system operations. Regional capitals like Accra and Koforidua received their first supply in 1922 and 1926 respectively. By 1955 towns like Cape Coast, Tema, Bolgatanga, Tamale, Kumasi, Nsawam, Dunkwa, and Oda had been supplied with electricity from three major power stations at Cape Coast (1932), Swedru(1948) and Keta (1955). The electricity supplied from these sources were said to be inadequate to meet the demands of the time.

The „hydro-years" came about as a result of the insufficient and unreliable power supplied in the "before Akosombo" years for industrial purposes. Due to Ghana"s endowment with bauxite deposit, there was the need for a more reliable and less costly electricity supply alternative. The Akosombo dam was thus constructed to provide industries with reliable and cost effective source of power (ISSER 2005). According to Amuzu (1999), as at 1972, the Akosombo dam could generate 912MW of electricity. By the end of 1975, the total installed power generation capacity in Ghana had risen to 1,072MW after the construction of the Kpong dam. Despite the increased amount of electricity generated in Ghana, ISSER (2005: p. 20) asserts that the total domestic consumption doubled from 540GWh in 1967 to 1,300GWh in 1976 and has since been increasing steadily. This implied the need to expand the electricity generational capacity in Ghana.

Despite the increasing pattern of electricity consumption in Ghana, the available sources have been unreliable. According to Edjekumhene*et al.* (2001), a prolonged drought in 1983-84 severely curtailed the power generation capabilities of the plants as the water level in the Volta Lake reduced drastically beyond the minimum operational level of 278 feet. The 1983 drought led to mandatory power rationing, hence curtailment of power to all customers of VRA. The drought led to a 50 per cent cut in electricity exports to Togo and Benin and 95 per cent cut to VALCO. This introduced the „thermal complementation period" which is run by fossil fuel (crude oil) with the major thermal stations located in Tarkoradi (Thermal Station - 550MW) and Tema (Diesel Power Plant at Tema -30MW). Currently, due to several energy crisis and dwindling water levels in the various dams, the Bui dam is under construction to produce 400MW to relieve dependence on the other power generators in the country.

Green (2000) and ISSER (2005) indicate that there is an increasing demand for electricity for industrial, commercial, administrative and residential purposes in Ghana. Based on this exposition, this section of the study compares the current and future demand of electricity with the capacity to supply electricity to meet the increasing demand. According to Green (2000), the demand for electricity has been increasing at an average annual rate of 12 per cent since the last 10 years (1999-2009). In its contribution to the claim that electricity consumption has increased over the years, ISSER (2005) revealed that domestic electric energy consumption in 2004 was 6,004 GWh but was expected to increase to 9,300 GWh by 2010 (a percentage increase of 58.9 within 6 years). There is also the potential for significant electricity exports and supply to VALCO. However, the capability of Ghana"s hydro system is about 4,800 GWh and represents about half of the projected domestic consumption for 2010. This implies that at least 50 per cent of Ghana"s electricity requirement will be provided from thermal sources by the year 2010 (ISSER, 2005). In a similar vein, Akuffo (2009) reveals that Ghana"s electricity demand is expected to experience 23.5 per cent growth rate between 2008 and 2030.

The impact of electricity on productivity and growth has been the subject of numerous previous studies. Researchers have examined the relationship between electricity and productivity at the economy-wide level as well as at the firm level, the focus of this study. Labour productivity and total factor productivity have generally been the measures used in these studies. Researchers have considered the effects of access to electricity on firms" productivity, compared firms with and without electricity, analysed the effects of electricity price changes, and assessed the impact on productivity of electricity insecurity. In this section, the literature about the productivity effect of electricity access is reviewed first, before considering findings from previous studies about the impact of electricity insecurity and the findings from new analysis undertaken for this study.

2.6 Solar Energy Potentials in Ghana

The average duration of sunshine varies from a minimum of 5.3 hours per day in the cloudy forest region to about 7.7 hours per day from the dry savannah region. The average peak sun hours in Ghana varies from 5.0 to 5.7 peak hours with Kumasi having the average peak sun of 4.5 (Dadzie, 2008). According to Afoana and Asante (2015), the electricity consumption is mainly into household or residential, commercial, industrial and the agricultural sectors at rural electrification rate of 52% as compared to urban of 90%, Ghana aims at achieving 30% rural electrification through decentralized renewable energy for the residential sector by the year 2020.

Across the country, sixteen rural communities located in seven districts: Northern, Upper East and West, Volta, Brong-Ahafo and greater Accra have been provided with Solar PV facilities.(Ghana Statistical Service, 2007).These communities were identified with relatively high poverty levels. The beneficiaries of these solar home systems were not to pay any bill except to replace their own bulbs and other Balance- of-Components (BOCs), minor maintenance work (Energy Commission, 2005). Additionally, other communities with similar conditions who are not connected to the national grid, off grid electrification using solar home systems are been explored as an alternative technology (Ahiataku, 2003).

The Ministry of Energy and Petroleum (MOEP) projected an augmentation of the contribution of RETs to the national energy generation mix from less than 1% currently to 10% in 2020 (Ahitaku, 2003). To help realize this ambitious energy target, demonstrable efforts have been made through the implementation of some notable solar projects such as the Renewable Energy Services Project (RESPRO) in 1998 and the Renewable Energy Development Project (REDP) in 2000 as well as the Ghana Energy Development and Access Program (GEDAP) in 2007. As at 2011, a total of about 106 CHIPS compounds were provided with about 316 Solar Home Systems (SHSs), Solar Street Light (SSLs) and five thousand (5000) solar lanterns are to be distributed to augment the lighting needs of these impoverished rural communities identified in the selection across the length and breadth of the country in the first phase of implementation (Nsiah-Gyabaah, 1994; Addo, 2007). The rationale for targeting rural clinics in the first phase of GEDAP was probably motivated by the critical role these health centers play in saving many lives in less privileged rural communities where maternal and infant mortality rates are likely to be high.

Again according to Naah and Hamhaber (2015), the second phase of GEDAP focused on its individual ownership policy and was piloted in districts of Sissala West, Sissala East and Lawra/Nandom. The rationale was partly to make SHSs more affordable and accessible to interested low income rural householders to improve their livelihood. A study by Obeng and Evers (2009), looked at the specific role of energy in achieving MDG goal 1(universal access to energy) in Yoyo. Bawakyillenuo (2007) found that, rural electrification plays a critical role on the family planning practice in two communities; Kpassa and Tengzuk in Nkwanta and Talensi districts in Volta and Upper East regions respectively because of similarity in population, terrain and climate. The quantitative impact of solar PV on hours of usage in radio and television in particularly off grid communities (Obeng et al., 2009) appears generally to agree that immediate benefit of solar PV comes through improved lighting for powering electronics devices such as radio and television which significantly contribute to increase access to information and entertainment at household levels as reported by Wamukoya and Davies (2001). In 1991 there were about 335 solar PV systems installations in Ghana with a total estimated power of about 160KW (Obeng et al, 2009).The 1990 and 2003 years are postulated to represent significant turning points of solar PV projects in the country. Commitments from government to enforce the NES in the 1990s saw a sharp increase in PV systems from 700KW in 1993 to 2,530KW in 1998 and by 2003 about 4,911PVsystems were installed with total power of 1.0 peak megawatt (Bawakyillenuo, 2007).

Solar energy has been utilized in so many different ways in Ghana over the past twenty years. Solar energy systems mostly installed by Non-governmental Organizations and public institutions number over 5000 across the country. The installed capacity of almost one megawatt can generate between 1-2 gigawatt-hours per annum (Bawakyillenuo, 2007). The breakdown of the applications of the dramatic rise in the implementation of connected photovoltaic systems in Ghana is shown in Table 1.

Table 1: Breakdown application of solar PV in Ghana

SOLAR PV SYSTEM	Installed capacity (kWp)	Generation in GWh
Rural Solar home system	450	0.70-0.90
Urban solar home system	20	0.05- 0.06
Systems for schools	15	0.01-0.02
Lighting for health centers	6	0.01-0.10
Vaccine Refrigeration	42	0.08-0.09
Solar Water pumps	120	0.24- 0.25
Telecommunication	100	0.10- 0.20
Battery charging stations	10	0.01- 0.02
Grid connected systems	50	0.10-0.12
Solar streetlights	30	0.04 – 0.06
Total	**843**	**1.34 -1.82**

Ministry of Energy, (2003)

2.7 Solar Photovoltaic System Configuration

Photovoltaic (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process take place involving crystallized atoms being ionized in a series, generating an electric current. These solar cells are typically grouped into modules that hold about 40 cells, and about 10 of these modules are then combined to form the PV array, which is usually several meters to a side. PV arrays can be mounted at a fixed angle facing south, or on a tracking device that follows the motion of the sun across the sky Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet"s most plentiful and widely distributed renewable energy source – the sun.

The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. It is well proven, as photovoltaic systems have now been used for fifty years in specialized applications, and grid-connected PV systems have been in use for over twenty years. They were first mass-produced in the year 2000, when German environmentalists including Eurosolar succeeded in obtaining government support for the 100,000 roofs program. Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic has declined steadily since the first solar cells were manufactured, and the levelized cost of electricity from PV is competitive with conventional electricity sources in an expanding list of geographic regions. Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity, have supported solar PV installations in many countries. With current technology, photovoltaic recoups the energy needed to manufacture them in 1.5 to 2.5 years in Southern and Northern Europe, respectively.[8] Solar PV is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity. More than 100 countries use solar PV. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building (either building-integrated photovoltaics or simply rooftop).

In 2014, worldwide installed PV capacity increased to at least 177 gigawatts (GW), sufficient to supply 1 percent of global electricity demands. Due to the exponential growth of photovoltaics, installations are rapidly approaching the 200 GW mark – about 40 times the installed capacity of 2006. China, followed by Japan and the United States, is the fastest growing market, while Germany remains the world's largest producer, with solar contributing about 7 percent to its annual domestic electricity consumption. A household can be powered using 10-20 PV arrays, while utility-scale PV power generation requires hundreds of connected arrays. Most areas in the United States have enough sunlight for cost effective, small-scale, non-grid connected PV, but not all areas have sufficient sunlight for utility-scale PV power generation. A modern PV array can be seen in Figure 1.

Figure 1: Modern photovoltaic (PV) array. Source: Tse, (2000).

There are several advantages to the use of solar power. It does not degrade air or water quality and does not produce any CO2 emissions. Unlike many other forms of power generation, it does not require the extraction, transportation, storage, or combustion of fuels. Some solar power systems have no moving parts, reducing maintenance costs. Also, while CSP technologies are still in relatively early stages of development, PV is a well-established technology.

A significant advantage of CSP technologies is that these systems are readily scalable. They can be sized to generate several kilowatts of power for a single community or hundreds of megawatts for a grid connected application. A further advantage specific to power tower systems is that molten salt retains heat well, so it can be stored for days before being used to produce electricity. This can help to mitigate the variable availability of solar resources by allowing the power tower system to provide power on cloudy days or even after the sun has set.

High capital cost is a major, though not insurmountable, issue for solar power. Another significant issue is that resource availability depends on the time of day and the weather. This leads to daily and seasonal fluctuations in solar power generation. Technologies that track the movement of the sun and efficiently store energy, such as power tower systems, can help to mitigate this variability. Furthermore, solar resource availability is often positively correlated with demand; more sunlight is available during the summer months, when peak electricity demand is often highest, which also helps mitigate the issue of intermittency.

One issue with PV technologies is that their efficiency is low compared to those of traditional fossil fuel or nuclear power plants. Commercial PV cells typically exhibit efficiencies of roughly 15 percent. Also, very large surface areas are required for utility-scale PV power generation. Although the Great Plains and upper Midwest feature many large open spaces that could be repurposed for PV power generation, this would preclude any other use of that land. (This is in contrast to wind power, which minimally disrupts other land uses.) Utility-scale PV power generation therefore may be more feasible in the relatively arid Southwest. This aridness, however, can pose a challenge to solar power technologies that require water to produce steam and for cooling.

There are many small, stand-alone applications for solar power, most of which use PV technologies, though some may rely on small dish-engine systems. Businesses can use PV for heating and cooling, various industrial processes, and water heating.

Homes can use PV for heating and cooling as well as water heating, and may even produce enough electricity with PV to operate off of the grid. Businesses and homes may be able to use PV to reduce electricity bills by selling excess electricity back to utilities. Such grid-connected solar systems have become a larger market than off-grid applications. Technologies are also being developed that will allow PV cells to be built directly into roofs, windows, and other structure element of building Communities and individuals can find many applications for small-scale PV in addition to those associated with buildings. PV can be used to power water pumps and communication equipment in remote areas. It is also well-suited for small electronics applications in which using PV is cheaper and cleaner than extending existing power lines.

2.8 Solar PV Electrification and Quality of live

Solar PV electrification can improve the quality of life of rural households through positive impacts that cannot easily be expressed in monetary terms (Addo, 2007). Quality of life is simply life goals expected to be fulfilled: better education, health, access to information, indoor lighting, among others. Significant impacts of solar PV systems include better quality of light, car batteries do not have to be transported, and indoor smoke and fire hazards from kerosene lanterns are reduced (Posorski, 1996; Obeng 2008). Furthermore, solar PV electrification contributes to improve quality of life in off-grid rural communities through the direct effect of the technology on household wellbeing and enterprise income (Fishbein, 2003; Martinot, 2004; Posorski, 1996). It should be stressed that the gradual replacement of fossil energy electrification with renewable will not provide all the energy needs for quality of life improvements.

However, there are many applications that can improve the quality of life of rural households. These include among others the replacement of kerosene lanterns and candles with solar PV lighting (Plastow and Goldsmith, 2001). On the expenditure side, rural households in developing countries typically spend between $3 and $20 per month on kerosene, candles, or other energy products (Plastow and Goldsmith, 2001). With the use of kerosene and dry-cells, it is observed that monthly expenses can be as costly as US$ 10 per family (Lorenzo, 1994). Obeng et al, (2010) reported that in Sri-Lanka and Indonesia, recurrent costs on kerosene, candles and batteries could reach $10-$30 per month. These are relatively high expenditures. Though the use of solar PV may reduce the recurrent costs associated with the use of kerosene, candles, and batteries, the amount of the reduction is uncertain and therefore deserves research attention.

2.9 Solar PV Electrification and Rural Enterprises

Mostly electricity can run a motor for a grain mill to transform a manual subsistence household activity into an income-generating enterprise, or help transform a barely viable enterprise into a more sustainable one (Allderdice and Rogers, 2000). Small rural stores can also expand their inventory by adding items that can be preserved using solar-powered refrigerators (Allderdice and Rogers, 2000; Etcheverry, 2003).

For example, solar PV-powered icemakers can assist village microenterprises in fishing, sale of ice cubes and cold drinks especially in tropical countries. Solar crop drying by small electric fans that circulate air around a heated surface can be used to preserve crops for export. Solar PV electricity helps micro-enterprises to generate additional income by extending their working hours after dusk (Obeng, 2009; cited in Grameen Communications, 1999; Allderdice and Rogers, 2000; DFID 2002). According to Obeng (2009) there are so few published data that indicate in quantitative terms the additional incomes likely to be generated after sunset by different solar-electrified enterprises in rural areas of Ghana. Further, securing access to water plays a strategic role in ensuring agricultural production (FAO, 2005).

In this regard, solar PV water pumping can supply water for dry land irrigation. This helps to sustain the conditions under which agriculture can contribute to food security, income generation and poverty reduction (Meah; Fletcher and Ulah, 2008). However, the lack of proper maintenance of solar PV pumps has made some rural beneficiaries abandon them at the installation sites (Van den Akker and Lamba, 2002). Addressing energy issues related to agriculture and off-farm activities can help to increase prospects for income generation in rural households by providing energy for irrigation, food processing, food preservation, retail shops, carpentry shops, barbering saloons and many types of manual production during evening hours (Etcheverry, 2003; Martinot, 2004) as indicated in fig. 2.

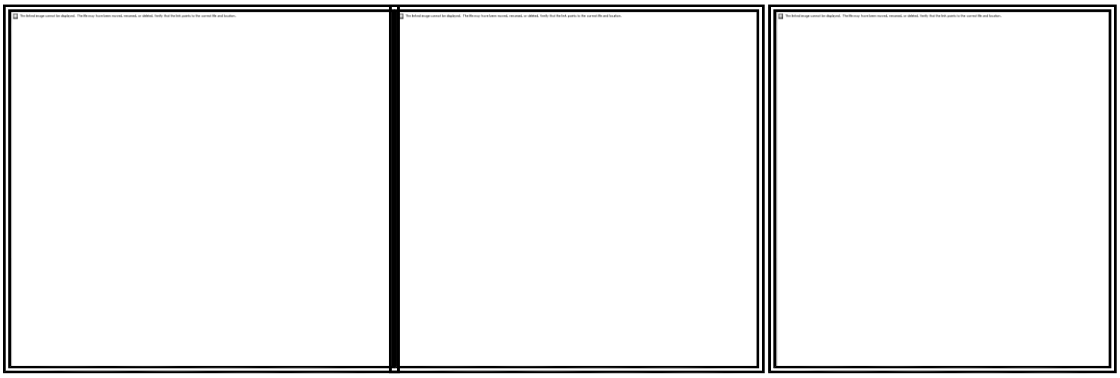


Fig. 2: Some Rural Micro-Enterprises. Source: Maleco, (2005)

2.10 PV System Economics

Cost of the solar photovoltaic (PV) system depends upon the power production (panel sizing), and storage (batteries) components. Although the operational cost of such systems is negligible, high initial investment is one of the main barriers for its wide scale adoption (Odeh; Yohanis and Norton, 2006). Improvement in efficiencies of solar panels, batteries, solar pumps, motors, and controllers has improved economic viability of the PV systems (Hankins et al., 2009). A dramatic drop in panel prices has been observed over the last three decades (Gilbertson and Kelly, 2010). However, a vigilant economic analysis is still required for exploring the application potential of the technology. Procedures have been described in literature for evaluating the economic viability of PV systems and along with its comparison with other conventional power sources such as electricity and combustion engines (Odeh et al., 2006; Meah et al., 2008; Kelly et al., 2010).

Many have questioned why with so much abundant solar resource, Ghana has a low implementation level of PV systems. The following are the key barriers;

- High initial installation cost
- Lack of Information, Market knowledge and Technical training
- Governments perceived lack of support to the solar industry.

2.11 National Policies

The 1973 oil shocks and concerns about global warming from the late 1980s are two developments that could have led to greater use of renewable energies (Obeng et al, 2009). However, national policies and political support have remained weak. The global growth rate of 20% for solar PV is a reflection of the current lack of political support for the rural off-grid sector (Plastow and Goldsmith, 2001). By contrast, in the developed countries, where government support schemes and targets are in place, growth rates for solar PV have exceeded 70% in recent years (Sawin, 2004). In Ghana, government support schemes, particularly the National Electrification Scheme backed by donor assistance have greatly influenced an increasing trend in installed power of solar PV from 160kWp in1991 (Institute of Economic Affairs, 2013) to over 1 MWp in 2003 (Ministry of Energy, 2003).

In spite of the steady growth in solar PV applications over the years, its overall contribution to the total energy consumption of Ghana has been only 0.02% (Ghana Statistical Service, 2007). Although rural electrification is of crucial concern to the Government of Ghana (Energy

Commission, 2005), data on the benefits of integrating renewable such as solar and biomass into large scale rural electrification programmes are uncertain. Without an effective evaluation of existing solar PV electrification projects, governments may not be fully convinced of the benefits that can be derived from full scale implementation of solar PV projects to increase access to electricity to reduce energy poverty in off-grid rural and peri-urban areas. To realize the energy vision of Ghana, solar energy had been identified among the key energy sources for long-term development and sustainability of electricity supply to increase access, particularly for rural poverty reduction (Ministry of Finance, 2000). And this objective is addressed by the Strategic National Energy Plan, SNEP (Energy Commission, 2005). Although there was little credit available for purchasing solar PV systems privately, the Government of Ghana took steps including fee-for-service approach to encourage the use of PV systems in off- grid rural areas (Institute of Economic Affairs, 2013).

Under the National Electrification Programme (NEP), the Off-Grid Solar Electrification Projects were administered by the then Ministry of Mines and Energy (MOME), Ghana with internally generating continuous financial resources, the projects could not effectively increase local manufacturing capacity in the design and installation of PV equipment and components (Obeng, et al, 2008). The projects also encountered some barriers and challenges which require in depth study and analysis to enhance policy and planning of future PV electrification projects in Ghana and other African countries in generated financial resources (Institute of Economic Affairs, 2013).

2.12 The Effects of Electricity Insecurity

Most studies of the relationship between electricity and productivity have focused on the difference that electricity consumption makes. Research taking account of the quality of the electricity supply has received less attention, and often been based on small, country- specific studies. The quality of electricity supply, measured in terms of outages and voltage fluctuation, varies considerably between countries but is rarely measured or described (World Bank 2010), and is thus more difficult to factor in. However, Sawe et al. (2001) found that poor infrastructure quality has a significant negative impact on total factor productivity, and that poor quality electricity supply is the infrastructure element that has the strongest negative effort on enterprise productivity, especially in poor African counties (Sawe et al., 2001). In a study of the impact of rural electrification on household income in India, it was found that the reliability of electricity supply is more important than being connected to the grid.

The impact of electricity insecurity on productivity at the level of the firm has been the subject of several studies using World Bank Enterprise Surveys and study-specific surveys, and employing a variety of methods. Studies look at cost of interruption, cost of back-up generators and effect on productivity (using a production function). Using World Bank Enterprise Survey data for over 1,000 firms in 10 Sub-Saharan African countries, Sawe et al. (2001) shows that, an unreliable electricity supply has a significant negative impact on a firm"s total factor productivity.

A study examining the impact of power disruptions on firm productivity in the manufacturing sector in Nigeria shows that power outage variables (measured using hours per day without power and percentage of output lost due to power disruptions) have a negative and significant effect on productivity (Rogerson, 2001). The analysis for this study found that power outages have a negative and significant impact on productivity in small firms, but an insignificant effect in large firms, probably due to generator ownership patterns. It was obtained quite different findings in Senegal. Here, outages were found to have a positive and significant effect on the productivity of firms, and SMEs performed better than large-scale firms. The suggested explanation for this contradictory finding is that outages stimulated better management practices, which mitigated the negative effects of power supply interruptions, and that the more inefficient, lower productivity firms had gone out of business in the face of electricity insecurity. The deployment of solar PV in rural and peri-urban areas in most African countries is primarily meant to address the problem of low access to grid-electricity. The absence of energy services such as lighting or motive power provided by electricity to support socioeconomic development is described as energy poverty (Obeng et al, 2008).

In spite of governments‟ intention to increase the use of renewable energy in electricity supply, particularly the use of solar PV for energy poverty reduction in rural and peri-urban areas of Africa, there is relatively little information on the relationship between solar PV electrification and energy poverty reduction. Therefore there is a gap in literature and hence the need for continuous research. Although electricity per se does not alleviate poverty, its link to poverty cannot be denied (Department of Energy, 2004). Besides the harsh living conditions poor people find themselves, they also feel a sense of social exclusion (World Bank, 2000; Lorenzo, 2000). Social exclusion can happen when people or areas suffer from unemployment, poor skills, low incomes, unfair discrimination (Nelson, 2003). Given this context, it is therefore very crucial to „tie together" territorially disjoined or isolated rural areas, by providing a physical infrastructure such as electricity to increase social resilience as well as facilitate direct social production processes (Nelson, 2003). The promotion of knowledge on this linkage is important, because various poverty reduction strategies (PRS) for multilateral assistance have rural electrification components. For example, within the framework of the National Electrification Scheme (NES) of Ghana and the Ghana Poverty Reduction Strategy (GPRS), solar PV electrification is included as an integral part of rural electrification (Institute of Economic Affairs, 1999; Energy Foundation, 2004).

CHAPTER THREE

METHODOLOGY

The authenticity of a research largely depends on the methods adopted in collecting and analyzing the data. The research methodology involved the uncovering of the practices and assumptions of different kinds of methods. These chapter shows the procedure used in conducting the survey.

3.1 Research Design

A variety of instruments are used in research design strategies for collecting the data (Saunders et al, 2009) namely experiment, survey, action research, grounded theory, ethnography and archival research. In this study a convenience sampling technique was used. The instrument used in collecting the data was questionnaire and interview. The interview and the questionnaires were prepared to solicit information after an intensive review of literature, textbooks, internet, publications and journals. The questionnaire comprised of two parts; the first section consisted of demographics of shop owners while the second part handles the usage and impact of PV systems in their jobs where test items were measured on a five point Likert- scale (1=strongly disagree, 5=strongly agree) and sought to find out from shop owners about the level of agreement or disagreement on the impact of solar PV on their enterprises.

3.2 Population

The populations for the study were shop owners in the Twifo-Heman rural communities that were off-grid, and not covered under the Self Help Electrification Project (SHEP) because of their locations. They were among the lists of the beneficiaries of solar PV electrification projects in rural Ghana GEDAP in 2002. The enterprises surveyed were generally small-scale employing less than six people. They were mainly shops engaged in the sale of groceries (village supermarket), chemicals (drugs), tailoring, drinking bars, spare parts, electronic repairs and video show businesses. However, grocery shops, chemical shops, drinking bar and tailoring were the predominant enterprises in all the communities. Gari processing and palm oil extraction were also identified in these communities are located behind the Prah River in Twifo-Heman in the central region of Ghana.

3.3 Sampling Procedure and Sample Size

Purposive sampling technique was used to select the business owners for a face-to-face interview because of solar PV facilities in their shops. The survey was used to find out their impression or perception about solar PV systems as far as their businesses are concerned. In total, sixty (60) business owners with solar PV were interviewed. More males (57%) than females (43%) were surveyed. The average age of the respondents were between 31-40 years. Majority of them (54%) had attained junior high education. Again, the dominant enterprise was grocery shops (80%) and, 65% are married.

3.4 Instruments

Questionnaire was used as the data collection instrument to solicit information from the shop owners. For the purpose of the study, the questions were grouped under four main sections: social, economic, technical challenges, job performance before installation of photovoltaic energy and job performance after the installation of photovoltaic energy.

3.5 Data Analysis

The data was edited to detect and correct, possible errors and omissions that were likely to occur, to ensure consistency across respondents. The data was analyzed using Statistical package for Social Sciences (SPSS 17.0). Mean values were used by scoring the responses in and converting them into percentages. Data was presented in tabular form, graphical and narrative forms. The opinion with the highest response was considered the general view of the respondents.

CHAPTER FOUR

PRESENTATION OF RESULT AND DISCUSSION

This chapter presents the results of the field work. The backgrounds of the respective participating shops Small Medium Enterprises (SMEs) are discussed in this section. This aspect of the analysis seeks to delve into the background of the respondents in order to ascertain the degree of credible information for the study; named according to personal and business characteristics. The study achieved 100 percent response rate. The study estimated sample size of 60 respondents and was achieved successfully.

4.1 Personal Characteristics of the Respondents

This section of the demographic analysis delved into the personal characteristics of the respondents. It consists of the age of respondents, gender, marital status and average monthly income. Table 2 represents Demographics of Respondents.

Table 2: Demographics of Respondents

Demographics	Frequency (n)	Percent (%)
Gender		
Male	34	57
Female	26	43
Age		
Below 21- 30yrs	12	20
31 – 40 years	25	42
41 – 50 years	15	25
51-60 years	8	13
Education		
No formal	12	20
Basic	22	37
Senior High	20	33
Tertiary	6	10
monthly Income		
Less than ₵100	20	33
₵100 – 300	25	42
₵300 – 500	15	25
Above₵ 500	0	0

Table 2 reports the demographics (gender, age, education, income) of shop owners. In terms of gender composition, more men (57%) than women (43%) shop owners were surveyed. The male gender of the respondents were involved in groceries (retail supermarket), tailoring, spare parts shops, chemical shops, electronics and video show business (sales of CDs, cassettes and video shows in the night). The female gender were also more in hairdressing saloons and seamstresses. Some of the female were together with the male operating groceries (retail supermarket) and dinking bar. The responses was skewed towards males because in Ghanaian traditional setting, males are the heads of their family, main decision makers and so women must seek permission from their husbands before speaking to the interviewer. In the case of age, majority (42%) shop owners were in the 31-40 year group whereas 13% represented the least average age between 51 and 60 year group.

The distinction patterns may be due to age-wealth and age technology issues. In rural Ghana, the imbalance in resources between the youth and older people ultimately determine the choices of their needs (Bawakyillenuo, 2007). Moreover, younger people tend to be more adventurous and greater affinity with new technology, compared to the more cautious nature of the elderly. Educational attainment was a key factor which influences the understanding of the adoption patterns of solar PV in rural Ghana. Majority (80%) had attained education from basic to tertiary level whereas (20%) had no formal education. Among the educational levels, majority (37%) had attained basic education (Table 2). It can be argued that, the non- formal education could be due to the lack of enthusiasm for education in the past and with the main economic activities being farming, education could reduce the family labour. Table 2 further reports the monthly average income of shop owners. Majority (42%) earns between GH¢100-300. followed by below ¢100 (33%). One- fourth (25%) earns between GH¢300-500 whereas none was recorded above GH¢500. Table 3 shows number of dependents on shop owners.

Table 3: Number of Dependents on shop owners

No. of Dependents	Frequency (n)	Percent (%)
1-2	15	25
3-4	19	32
5 or More	26	43
Total	**60**	**100**

Source: Field Survey, 2015

Table 3 shows the number of dependents of the respondents. There weren‟t any of the respondents who had no dependents. It was observed that, majority 25(43%) were having 5 or more dependents, followed by 19(32%) for 3-4 dependents and 15(25%) for 1-2 dependents. Table 4; illustrate business categories of the respondents.

Table 4: Business Categories of the Respondents

Categories	Frequencies(n)	
Groceries (retail supermarket)	6	10%
Chemical (drug)	13	22%
Tailoring	14	23%
Drinking bar	6	10%
Spare parts shop	4	7%
Electronic repair shop	6	10%
Video Show Business	4	7%
Seamstress	7	12%
Total	**60**	**100%**

Source: Field Study, 2015

Table 4 reports the covered micro-enterprises categorized in the study as follows; groceries, chemical shop, tailoring and seamstress, drinking bars, spare parts, electronic repair and video show businesses. Groceries, drinking bars and electronic repair shops were 10% each. There were 22% chemical shops (drug), 23% tailoring, 12% seamstress, 7% spare parts shops and video show businesses each. The study encompassed these eight business categories which were observed to be benefiting from solar PV system as source of energy. The dominant micro-enterprise was chemical (drugs) (23%) whereas video show and spare parts shops had the least number of respondents (7%).

Table 5: Business Characteristics of Respondents

Variables	**Categories**	**Frequencies(n)**	**Percentage (%)**
Electrical gadgets	T.V	14	23
	Radio	9	15
	Fan	32	53
	Refrigerator	5	8
No. of years of Business	1-5years	16	27
	6-10years	25	42
	11-15years	10	17
	16<	9	15
No. of employees	1-2people	56	93
	3-4peoples	4	7
Kind of energy used before	Kerosene	36	60
	Diesel	1	2
	Car battery	7	12
	Dry cell	16	27
Dominant energy services used	Light	11	18
	Light & Fan	24	40
	Light, Fan & Business activity	25	42
	Total	**60**	**100**

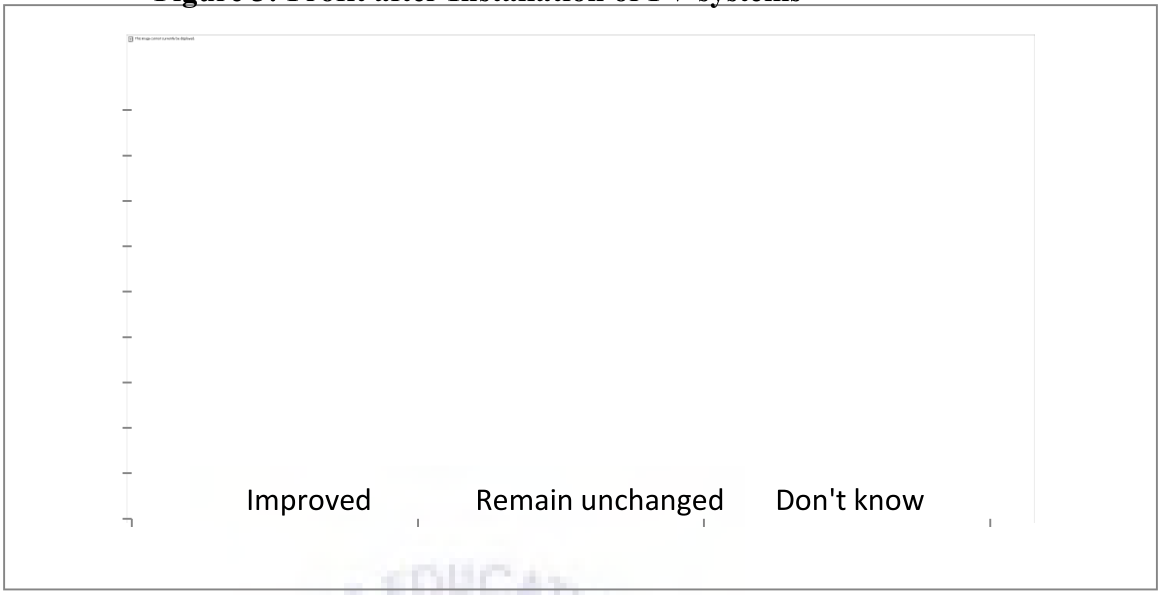
Source: Field Survey, 2015

Table 5 shows the various characteristics of the micro-enterprises. The study observed that, the dominant electrical gadget used by the micro-enterprises was fan (53%), followed by T.V (23%) and Radio (15%). The least electrical gadget used was Refrigerator (8%). The number of years respondents have been in business was also observed (Table 5). Majority (42%) of the respondents have been in business for 6-10 years, followed by 1- 5yaers (27%) and 11-15 years (17%). Respondents in the category of 16 years and above had the least (15%) of respondents.

The kind of energy source used by micro-enterprise shop owners before solar PV was introduced was observed in Table 5. More than half (60%) used kerosene, followed by dry cell (27%), and car battery (12%). Diesel (2%) had the least respondents among the shop owners.

Again, respondents were asked to indicate the dominant energy services of their enterprises. It was found out that, the dominant energy services used by shop owners was lighting, fan and business activities (42%), followed by lighting and fan (40%) whereas, lighting only had (18%) of the share.

Figure 3: Profit after Installation of PV systems



Shop owners were asked to indicate their profit level after the installation of the solar PV system in their enterprises (Fig. 3). The study found out that, greater percentage (90%) of the shop owners indicated improved profit in their enterprises, whereas 5% indicated unchanged profit in their enterprises. Also, 5% of the shop owners indicated they don‟t know if their enterprises have profit or not.

Table 6: Frequencies and mean scores for social impact of PV systems in rural electrification

Statement	5 %	4 %	3 %	2 %	1 %	M	SD
1. PV has reduced environmental pollution	40	27	14	15	4	3.37	1.42
2. PV has improved access to information	24	45	7	13	11	3.10	1.23
3. PV system has enhanced entertainment	30	39	3	19	9	3.22	1.47
4. PV system has improved educational delivery	29	27	11	13	20	2.94	1.38
5. PV system has enhanced security	21	33	25	6	15	3.03	1.24
6. PV system has improved health delivery	52	25	2	12	9	3.67	1.28
7. Privacy has improved through PV system	32	25	23	8	12	3.17	1.25
8. Local capacity for women empowerment has improved	38	30	9	11	12	3.33	1.39
9. Solar PV systems has replaced dirty energy source for lighting	85	11	4	0	0	4.16	1.14
10. Availability of PV systems has improved community social activities	50	22	13	12	3	3.93	2.95
11. I feel proud of having PV system in my household	44	31	5	10	10	3.67	1.28

Key: Strongly agree=5; Agree=4; Neutral =3; Disagree=2; Strongly disagree=1

Shop owners were requested to indicate their responses on the social impact of solar PV systems in rural electrification (Table 6). Shop owners indicated significantly concerns about social impact of solar PV, majority (96%) “agreed” or “strongly agreed” that solar PV has replaced „dirty" energy source for lighting. Seventy-two percent agreed or strongly agreed that, PV system has improved community social services. The statement “PV system has improved health delivery” had an acceptance of (M = 3.67) while 75% feel proud of having PV system in their households. More than half (67%) agreed that PV system has reduced environmental pollution. Improvement in local capacity for women empowerment was endorsed by 68% of the household heads. Again, households perceived PV has enhanced entertainment (M = 3.22), followed by privacy (M = 3.17) and information access (M = 3.10).

Table 7: Frequencies and mean scores for economic benefits of solar PV in rural electrification

Statement	5 %	4 %	3 %	2 %	1 %	M	SD
1. Improved income generating activities.	29	28	23	21	9	3.22	1.47
2. Has reduced unemployment in the area.	25	34	15	12	14	3.29	1.17
3. Reduced household expenditure.	38	30	5	16	11	3.38	1.49
4. Has reduced time to perform household chores.	45	52	3	0	0	4.30	0.96
5. Has drastically reduced electricity bills.	40	33	7	9	11	5.57	1.33
6. Poverty levels have reduced through household income.	38	30	9	13	10	3.55	1.31
7. PV systems service is affordable for users.	29	11	15	16	29	2.98	1.32
8. I feel motivated to conserve energy through PV systems.	32	36	10	4	18	3.33	1.39
9. I have plans to upgrade my PV system in the future	36	24	11	14	15	3.28	1.46
10. PV system have affected my electricity consumption rate	24	12	22	19	23	3.23	1.27

Key: Strongly agree=5; Agree=4; Neutral=3; Disagree=2; Strongly disagree=1

Table 7 reports shop owners‟ responses to economic benefits of solar PV in rural electrification. The mean (M) responses of nine out of the ten statements were above the threshold value of 3.0, suggesting that households generally perceive solar PV in rural electrification to be economically beneficial. The statement “PV has reduced time to perform household chores” had the highest acceptance (M = 4.30), followed by “PV has drastically reduced electricity bills” (M = 4.04) and “reduced poverty level” (M = 3.55). Thirty-eight percent strongly agreed that PV system have reduced household expenditure while 36% agreed they feel motivated to conserve energy through PV systems. Thirty-six percent strongly agreed to upgrade their PV systems in the future.

Table 8: Frequencies and mean scores for challenges of PV systems in rural electrification

Statement	5	4	3	2	1	M	SD
	%	%	%	%	%		
1. Lack of resources to expand the facility	53	40	6	1	0	3.68	1.25
2. Low generation capacity	66	33	1	0	0	3.72	1.36
3. Low technical expertise	53	36	8	2	1	3.45	1.26
4. High cost of installation	80	18	2	0	0	4.04	1.19
5. Power fluctuations are regular	34	24	26	8	8	3.23	1.27
6. Risk or hazard of electrical shock is minimal	61	16	11	7	5	3.37	1.38
7. Irregular supply of spare parts	46	46	6	2	0	3.29	1.05

Key: Strongly agree=5; Agree=4; Neutral=3; Disagree = 2: Strongly disagree=1

Table 9: Frequencies and mean scores for challenges of PV systems in rural electrification

8. Frequent purchase of florescent bulbs due to outdated equipment	44	36	13	4	3	3.34	1.29
9. Frequent malfunctioning of batteries PV Services	5	8	10	34	43	3.18	1.36
10. Advanced notice about planned service disruption is given to users	35	24	6	15	20	3.21	1.27

Key: Strongly agree=5; Agree=4; Neutral=3; Disagree = 2: Strongly disagree=1

Table 8 and 9 show households responses to challenges of PV systems in rural electrification. The mean (M) responses of the ten statements were above the threshold value of 3.0, suggesting that households generally perceive solar PV in rural electrification to be challenging. The statement "high cost of installation" had the highest acceptance (M = 4.04), followed by "low generation capacity" (M = 3.72) and "lack of resources to expand facility" (M = 3.68). Eighty-nine percent agreed or strongly agreed that low technical expertise is a challenge in PV electrification while 77% agreed that risk or hazard of electrical shock is minimal in solar PV systems. More than half (80%) agreed that irregular supply of spare parts pose a serious challenge to solar PV. The frequent purchase of electrical bulbs due to outdated equipments was endorsed by 80% of the households.

Table 10: Job Performance before installation of PV

Statements	SD %	D %	N %	A %	SA %	M(±SD)
PV energy sources has improve turnover of ME‟s.	3.4	1.7	9.5	31.9	53.4	4.30(0.962)
The introduction of PV has led to prevalent use of more machinery.	12.3	7.9	19.3	31.6	28.9	3.57(1.317)
You are not satisfied with your current power source	10.4	12.2	19.1	28.7	29.6	3.55(1.313)
Increased income improved business wellbeing before PV.	20.7	8.6	11.2	31.9	28.4	3.38(1.498)
There were more employees before the Installation of PV systems	16.7	10.0	20.8	28.3	14.5	3.33(1.386)
There was diversification of services before the installation of PV system	9.5	12.1	35.3	25.9	17.2	3.29(1.172)
There was improved quality of product/services before the installation of PV system	20.7	6.0	25.9	19.8	27.6	3.28(1.460)
I operated my enterprise for more hours before the PV system installation	13.3	14.2	25.7	19.8	27.6	3.23(1.268)
There were time saved through reduce operation and maintenance	19.1	7.0	23.5	23.5	27.0	2.98(1.319)

Source: Fieldwork, 2015 SD= Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree

Table 10 shows shop owners‟ responses to job performance before PV installation systems in their enterprises as far as rural electrification is concerned. The mean (M) responses of the nine statements were above the threshold value of 3.0, suggesting that shop owners‟ generally perceive solar PV installation in rural electrification to very crucial. The statement "PV energy sources has improve turnover of ME‟s" had the highest acceptance (M = 4.30, ±SD= 0.962), followed by "The introduction of PV has led to prevalent use of more machinery" (M = 3.57, ±SD= 1.317) and "You are not satisfied with your current power source" (M = 3.55, ±SD= 1.313). Fortythree percent agreed or strongly agreed that there were more employees before the Installation of PV systems while 78.4% agreed that there was diversification of services before the installation of PV system. More than half (73.1%) agreed that there were improved quality of products/services before PV installation. The time saved through reduced operations and maintenance was endorsed by 50.5% of the shop owners".

Table 11: Job Performance after PV installation

Statements	SD %	D %	N %	A %	SA %	M(±SD)
More hours may result in extra income in PV usage.	5.2	4.3	15.5	27.6	47.4	4.08(1.128)
PV has increased income and improves business wellbeing	12.9	9.5	23.3	31.9	22.4	3.41(1.293)
Installation of PV systems has increased my employees	17.2	9.5	13.8	36.2	23.3	3.39(1.394)
PV system has enabled my enterprise to operate for night hours	8.6	18.1	25.9	32.8	14.7	3.27(1.175)
Availability of the PV system has improved quality of my product / service	13.8	12.9	29.3	24.1	19.8	3.23(1.295)
Availability of PV systems has necessitated diversification of my services	9.6	18.4	36.8	22.8	12.3	3.10(1.136)
Solar PV has the rationale for planning and evaluation review of energy	19.2	21.6	19.8	22.4	16.4	2.94(1.379)

Source: Field data, 2015 SD= Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree

Shop owners were requested to indicate their responses about their job performance after PV installation in their enterprises (Table 11). Most of the mean values were above a threshold of 3.0, except for the last item on the table which recorded a mean of ±2.94. It is seen that the factor „more hours may result in extra income in PV usage" has the highest percentage (75.3%) and mean score (*M*= 4.30, ±SD=0.962). This is an indication of strong agreement with this item. It means that it is the most significant statement or factor for which shop owners adopted PV. More than half (54.3%) agreed solar PV has increased income and improve business wellbeing. The statement "installation of PV systems has increased my employees" had an acceptance (M= 3.39, ±SD= 1.394) and also agreed that PV systems has enable their enterprise to operate at night hours (M= 3.27, ±SD= 1.175). Again, shop owners were neutral on whether PV has improved their products/services (M= 3.23) but agreed PV has necessitated diversification of services (M= 3.10). The statement „Solar PV has the rationale for planning and evaluation review of energy" had the least acceptance share (M= 2.94, ±SD= 1.379).

4.2 Results

Before the introduction of electrification programme in the study areas, few micro-enterprises were found to operate by using either diesel for production or kerosene and candle for lighting as compared to after the electrification programme. This statement is supported by the fact that the number of micro-enterprises in electrified areas was more than number of MEs in un-electrified areas within the same village. This indicates that though the number of ME"s start up per year is small the emerging progress for MEs using electricity is growing. Before electrification programmes in the study areas, people were using kerosene lamps, candle or torch during the night for lighting, and used biomass energy for cooking and production. Students and residents were unable to study after sun set due to the lack of good quality lighting.

Due to increased access to electricity services (after installations) in rural areas, some productive uses have been identified through observation; these include lighting in shops and services activities, lighting and providing power in workshops such as carpentry, welding shops and grain milling. Availability of PV electricity services is one of the factors facilitating the decision of local entrepreneurs to invest in income generating activities such as milling machines, wood works, welding workshops, retail, saloons etc.

It was observed that the growth rate of micro-enterprises were noticeably higher in areas with enterprises using solar PV electricity services than in villages without electricity services, but the proportion was low compared to micro-enterprises growth rate and time of electricity introduction.

The growth of micro-enterprises was assessed by using the number of people involved in micro-enterprises activities after its establishment. micro enterprises owners interviewed said they had added at least one permanent employee since its establishment because there were enough activities and long working hours which needed assistance from these permanent staff, this was better when compared to non-electrified MEs which had none permanent employee. Others said they had remained stagnant from the time of their start-up to the date of the survey because the business was small in terms of turnover, which was small and could not lead to ability to pay additional salaries. People in those stagnant micro-enterprises were observed to be working either on a temporary basis or were paid in agreement on piecework or signed a short contract, as was the case in furniture manufacturers, chemical and tailoring shops in the study areas. The majority of micro-enterprisers interviewed in the study areas were one-owner micro-enterprises. This implies that micro- enterprises activities in Ghana are still low in the sense that there are small ranges of activities for existed SME"s, and they did not utilize productively the available opportunities such as PV electricity services.

Before the introduction of electricity services, there was only diesel engine grain milling for production, other enterprises such as retail shops were using kerosene lamp and candles for lighting. The observations in this study revealed that the availability of electricity services resulted in longer working hours and/or enable the change of some electrical machinery from diesel use to PV electricity use. This is one-step of growth in-terms of technology. James (1995) supports the argument by using the evidence from Indonesia that PV electrification of businesses led not to a significant increase in employment, but to extended working hours. Decline and closure of micro-enterprises were observed in the study area at a very low rate as a result of increase access to PV electricity services.

There were problems with regard to access and use of electricity for production purposes as observed by the researcher and reported by interviewees. These were:

- An initial connection fee was not affordable.
- The electricity services supplied was not reliable. The electricity

supplied was under voltage especially evening hours when it was difficult even to turn on a florescent light.

- There was bureaucracy from the grid electricity supplier staff. This means that there was unnecessary delay because from application date until get, approval for connection is a long period; sometimes people relate this with corruption.
- Lack of connection materials from electric supplier such as cables, poles and metres.
- Lack of capital to buy electrical equipments for their enterprises.

The availability of grid electricity services in rural areas stimulates establishment, growth and expansion of micro-enterprises at a low rate; also contribute to decline and closure of micro-enterprises due to market saturation and high competition. The livelihood characteristics of entrepreneurs and employees had changed as a result of taking up electricity services for production or operating the enterprises for example accumulation of physical assets such as T.V, radio cassette, and saloon dries etc. Financial assets had changed as well. There was increase in income earning which facilitated change in living standards like being able to pay good medical charges, school fees and good meal. In addition, human assets had increased; as observed, people gained business knowledge after dealing with customers for a long time; Young people gained knowledge and experience after they had participated in training like carpenters, welder and tailors etc.

It can be concluded that PV electricity services has more positive impact to enterprises using electricity both for lighting and production.

Interviewees‟ said they had witnessed noticeable growth and noticeable expansion as compared to those which used electricity services for lighting only. Also the decline and closure was more for enterprises which did not use electricity services for income generating activities as compared to electrified SMEs.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

The aim of this research is to investigate the impact of public solar PV electrification on rural micro-enterprises. This chapter presents summary of the findings, conclusions and recommendation for further study.

5.1 Summary of the Findings

The results show that the increased access to solar PV electricity services leads to changes such as establishment, growth and expansion of micro-enterprise such as grain milling, furniture manufacturer/carpentry, welding shops, tailoring shops, salons and retail shops.

In addition, growth of micro-enterprises in terms of numbers of workers and new technology in rural areas and establishment of new branches/expansion of micro-enterprises within and outside the villages were observed at a low rate. This may be more advantageous, if the solar PV electricity services supplied were available, reliable and affordable to most of rural poor people. Decline and closure of micro-enterprises were also observed in the study areas at a very low rate.

There were changes observed in livelihood characteristics of enterprises owners, people involved in the enterprises and community members where these enterprises located. For example, there were accumulation of physical assets such as T.V, radio cassette, mobile phones, and saloon driers among the interviewed enterprisers.

Again, financial assets had changed as well; there was increase in income earning which facilitated change in living standards like being able to pay good medical charges, school fees and good meal. In addition, human assets had increased; as observed, people gained business knowledge after dealing with customers for a long time; young people gained knowledge and experience after they had participated in training like carpenters, welder, tailors and barbers.

Lastly, barriers experienced by micro-enterprises during accessing and using solar electricity services identified such as fuses, cables, panels, inverters, controllers, bureaucracies, complicated tariff structure such as high initial connection and installation fees and high; illegal connection and vandalism of cables and low voltage supplied and fluctuation leading to causes blackouts, which discourage new customers to apply for connection.

5.2 Conclusion

In conclusion, the availability of solar PV electricity services supported development of micro- enterprise though at a low rate at village level. There is a direct link between arrival of rural electrification programmes and changes in micro-enterprises such as establishment, growth, expansion and decline and closure in the rural areas in Ghana. The study findings of this research revealed that there is a possibility of rapid emergence and development of SMEs in rural areas of the same characteristics as Twifo-Heman area if the solar electricity services supplied should be available, reliable and affordable to most rural poor.

It is believed that with time, it would be possible that rural communities would be able to take advantage of the opportunities provided by the introduction of solar PV electricity services by establishing more micro-enterprises to better their livelihood.

5.3 Recommendations

Barriers of development of micro-enterprises like lack of access to reliable electricity, markets, credits, business knowledge, materials, and effective transport and communication systems must be apriority to stakeholders. Against this backdrop, the following recommendations are made.

- Subsidies are very important if the adoption and utilization of solar PV is to grow in the rural areas. Studies are needed to understand the dimensions of subsidy capture of solar PV systems in rural electrification.
- Extensive assessment of the long-term efficacy and sustainability of solar PV in different energy demand activities or services (welding, irrigation, heating etc) should be done.
- Extensive educational campaign of solar PV technology impact on environmental pollution must be embarked to raise peoples" awareness of over-exploitation of tropical forest especially in rural communities.
- The lack of linkages between uses and impact of electricity services and micro enterprises establishment, survival, expansion, growth, decline and closure in rural areas in developing countries in general must be a necessity.

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APPENDIX

UNIVERSITY OF EDUCATION- WINNEBA COLLEGE OF TECHNOLOGY-KUMASI TECHNOLOGY DEPARTMENT

QUESTIONNAIRE FOR SHOP OWNERS

I am a student of University of Education-Winneba Kumasi and as part of my dissertation research; I am doing a survey about the impact of photovoltaic energy on the small scale enterprises in the rural communities.

SECTION A: PERSONAL DETAILS OF RESPONDENTS

Please [√] tick appropriate box

1. Age: 21-30 years: 31-40 years [ ] 41-50years [ ] 51-60 years [ ]
2. Gender: male [ ] Female [ ]
3. Marital status: married [ ] single [ ] divorced [ ] widow/widower [ ]
4. Number of dependent(s): None [ ] 1-2 [ ] 3-4 [ ] 5 or more [ ]
5. Business Category: [ ] Groceries (Village Supermarket) [ ] Chemicals (Drugs) [ ]

   Tailoring [ ] Drinking Bars [ ] Spare Parts [ ] Electronic Repair [ ] Video Show Business [ ] Others (Please Specify)…………………………….
6. What electrical gadget do you use? [ ] TV [ ] Radio [ ] Fan [ ] Light [ ] Business Activities [ ] refrigerator [ ] others (please specify)……………………
7. How often do you perform maintenance? [ ] Monthly [ ] Weekly [ ] Yearly [ ] Others………………………………………………………….
8. Number of years in your business.1-5 [ ] 6-10 [ ] 11-15 [ ] 16-20 [ ] 21 < [ ]

9. Number of employees: 1-2 [ ] 3-4 [ ] 5-6 [ ] 7-8 [ ] 9 and above [ ]

10. After installation of PV systems my profit have [ ] improved [ ] decreased [ ] remained unchanged [ ] don‟t know [ ]

11. What kind of energy did you use before? [ ] kerosene [ ] Diesel [ ] car battery [ ]

12. What is/are the dominant use/s of electricity of the enterprise [ ] Lighting [ ] Fan [ ] TV [ ] Business activities [ ] Radio [ ] others (Specify)…………………..

SECTION B: IMPACT OF SOLAR PV ELECTRIFICATION ON MICRO-ENTERPRISE

I. Job Performance Before The Installation Of Photovoltaic Energy

Please indicate the extent to which you agree with the items below.

Where **5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree**

No.	**Statement**	**Responds**				
		5	**4**	**3**	**2**	**1**
1	PV energy sources has improve turnover of ME"s					
2	The introduction of PV has led to prevalent use of					
3	Increased income improved business wellbeing before					
4	More micro-enterprises have improved local economy					
5	There were more employees before the Installation of					
6	There was diversification of services before the					
7	There was improved quality of product/services before the installation of					
8	I operated my enterprise for more hours before the PV					
9	There were efficiency in processes before PV was					
10	There were time saved through reduce operation and					

II. Job Performance After the Installation of Photovoltaic Energy

Please indicate the extent to which you agree with the items below.

Where **5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree**

No.	**S t**	**Responds**				
		5	**4**	**3**	**2**	**1**
1	PV Reliability energy sources have contributed to					
2	Savings made on PV energy services can be					
3	More hours may result in extra income in PV usage.					
4	PV has increased income and improves business					
5	More micro-enterprises have improved the local					
6	PV solar is justified for energy sustainability efforts.					
7	Solar PV has the rationale for planning and					
8.	Installation of PV systems has increased my					
9.	Availability of PV systems has necessitated					
10.	Availability of the PV system has improved quality					
11.	PV system has enabled my enterprise to operate for					
12.	Availability of PV systems has resulted in efficiency					

III. Economic Impact of Solar PV on Micro-Enterprise in Rural Electrification Please, indicate how you feel about the social impact of Solar PV Technology in rural electrification on the scales listed below.

No.	Statements	Responds				
		5	**4**	**3**	**2**	**1**
1	PV has improved income generating activities.					
2	PV system has reduced unemployment in the area.					
3	Availability of PV has reduced enterprise					
4	PV system has reduced time of business activities					
5	Availability of PV has drastically reduced electricity					
6	Poverty levels have improved through household income generating					
7	PV systems service is affordable for micro-enterprise					
8	I feel motivated to conserve energy through PV					
9	I have plans to upgrade my PV system in the future					
10	PV systems have affected my electricity consumption					

IV. Please, indicate how you feel about the social impact of Solar PV technology on micro- enterprise in rural electrification on the scales listed below; **5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree** **Social Impact of solar PV in Rural micro-enterprise**

No.	Statements	Responds				
		5	4	3	2	1
1	PV system has reduced environmental pollution.					
2	PV system improved access to information.					
3	PV system enhanced entertainment.					
4	PV system improved educational delivery.					
5	PV system enhanced security.					
6	PV system improved health delivery.					
7	Privacy has improved through PV system.					
8	Local capacity for women empowerment has					
9	Solar PV systems has replaced “dirty” energy source					
10	Availability of PV has improved community social					
11	I feel proud of having PV system in my shop.					

V. Please indicate the extent to which you agree with the following activities of micro-enterprise below. Where **5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly**

Challenges of Solar PV systems in rural micro-enterprise electrification

No.	Statements	Responds				
		5	4	3	2	1
1.	Lack of resources to expand PV system					
2.	PV system has low generation capacity.					
3.	There is low technical expertise in PV					
4.	High cost of installation of PV systems.					
5.	PV systems power fluctuations are regular.					
6.	Risk or hazards of electric shock is minimal					
7.	There is irregular supply of spare parts for					
8.	Frequent purchase of fluorescent bulbs					
9.	PV system service meets my demand					
10.	Advanced notice about planned service					