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The exploration of effectiveness of solar energy in Zimbabwe. The case of Murewa district.

BY

Kudakwashe Kobiri B192539B

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SUPERVISOR: MR. MANYEREDZI

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APROVAL FORM

The undersigned certify that they supervised, read and recommended to the Bindura University of Science Education for the acceptance of the research project entitled:

The exploration of effectiveness of solar energy in Zimbabwe. The Case of Murewa district.

Submitted by Kudakwashe Kobiri

In partial fulfillment of the requirements of Bachelor of Science Education.

Supervisor's name: Mr. MANYEREDZI

Signature…..…….. Date……../……/…….

(Signature of supervisor)

Name of student: Kudakwashe Kobiri

Signature……Date……../……/……

Name…….…… Signature……

(Chairperson)

Date……/……/…….

DECLARATION

I, Kudakwashe Kobiri, declare that this thesis is my own unaided work. It is being submitted in the fulfillment of requirements of the Bachelor of Science in education at Bindura University of Science Education (BUSE).

Student's signature… ……

Name……Kudakwashe……Kobiri……..

Date……

RELEASE FORM

NAME OF STUDENT Kudakwashe Kobiri

PROJECT TITLE: The exploration of effectiveness of solar energy in Zimbabwe. The case of Murewa district.

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DEDICATION

This project is dedicated to my mother and my friends DELIGHT, ANESU, NYASHA.I thank you for all the support I got from you, you encouraged me to be where I am today.

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ABSTRACT

The study was aimed at examining the effectiveness of solar energy in Murewa district, identifying key benefits, challenges and potential areas for improvement.Also the persistence energy shortages and the high dependency on non renewable energy sources that impede economic growth and social development in rural areas like Murewa.To address this the main objective was to evaluate the efficiency,cost effectiveness and socio-economic impacts of solar energy installations in the district.The study was both quantitative and qualitative in nature were a population of twenty six people and purposive sampling was used.The findings indicate that solar energy has significantly improved access to reliable and clean energy in Murewa enhancing the quality of life and fostering economic activities.Therefore, challenges such as high initial cost, maintenance issues and limited technical expertise were also identified.Based on these findings, the study recommends the establishment of local training programs to build maintenance skills.These measures are essential for scaling up solar energy adoption and ensuring it's long term sustainability in Zimbabwe.

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ACRONOMYS

(REAZ)…….Renewable Energy Association of Zimbabwe

(ZERA)……..Zimbabwe Energy Regulatory Authority

(LCOE)……..Leveled cost of electricity

NGO……Non-Governmental Organization

CHAPTER 1: INTRODUCTION

1.1 Introduction to the study

The purpose of the chapter is to cover the preamble of the research. It is going to explicitly explore the effectiveness of solar power on rural development in Zimbabwe, focusing more on Murewa District ward 30). This chapter is going to cover quite a number of sub- headings. Among others, these include; background of the study, statement of the problem, significance of the study, delimitations and limitations of the study.

1.2 Background of the study

Renewable energy resources are resources which are inexhaustible and can be used again and again. Among others, these include solar energy, wind energy and so. The sun provides resources which can generate clean and non- polluting and sustainable electricity, thereby resulting in reduced or no global warming emissions. Solar energy plays a significant role in the attainment of sustainable development goal of clean energy that is SDG7 (Franco & Taeihagh, 2024). Using green technology is crucial as it enables the meeting of demand with less environmental degradation. Solar PV system is the most common strategy of supplying energy. In Zimbabwe, the use of solar PV systems has increased tremendously as it has witnessed a more pivotal growth when compared to wind power. Solar power does not need the putting up of a power plant, extension of electric line, and purchase of fuel. It consumes only sunshine for power generation- nothing more.

Zimbabwe is located in Southern Africa, has a predominantly rural population, with an approximation of 67% of its population mainly residing in rural areas (Mutumbi et al., 2024). Zimbabwe's energy sector is mainly reliant on conventional energy sources such as fossil fuel, hydro-electric power and some coal-fired power plants. However, the existing energy infrastructure is largely concentrated in urban centres, leaving rural areas with limited or no access to electricity.

Zimbabwe makes use of several sources to meet their energy supply, biomass is the most important one and accounts for 50% of the total energy use. Over 80 percent of the population,

mainly living in rural areas uses firewood for cooking, lighting and heating purposes. Coal (12%) and electricity (13%) are the other two main energy types which provide energy supply (Tong et al., 2024). The electricity generation and distribution is the responsibility of the Zimbabwe Electricity Supply Authority (ZESA). Energy production in Zimbabwe is not sufficient to satisfy the domestic demand, and therefore 41% of electricity demand is imported from neighboring countries. These countries are often also faced with a shortage in electricity production which leads to a power shortage and power cuts (Mushosho & Qutieshat, 2024; Ngwenya & Hull, 2024). ZESA and the Zimbabwe government are therefore searching for solutions and investment possibilities to fight these supply shortage problems.

One of the aims of this research is to examine the ways in which the adoption of solar power has impacted rural development in Zimbabwe; in this regard, it is of importance to get a better insight in the current solar energy market and its players. Solar PV market in Zimbabwe has been more predominantly an urban market for the haves, or the urban affluent who buy them for their relatives in the rural areas. In addition, NGOs have formed the mainstay for providing solar PV in rural areas.

The solar energy that the sun radiates every hour is potentially sufficient to ensure one year world energy consumption. This is the case when all sunlight is captured and completely converted into electricity. Using current solar PV techniques leads to an average solar radiation potential of 1700 kWh per square meter on earth. Therefore hypothetical total solar energy potential worldwide is sufficient to meet the existing global energy use over 10,000 times (Omole et al., 2024; Zhu et al., 2024)

Kolie et al., (2024) posits that up to 32.5% of all health facilities in Zimbabwe lack electricity and quite a number do not have stable power supplies, thus compromising health service provision. Medical equipment cannot be operated or sterilized further impeding the implementation of infection prevention measures. Patient diagnosis, vaccination initiatives, or cooling of medical products such as blood or drugs are challenged by irregular or inadequate energy supply.

Gokwe is generally regarded as a very dry region and water access is a major challenge. Communities often have to travel long distances to the nearest isolated water points, usually a

borehole near either a school or a hospital. However, not all boreholes are mechanized, making it laborious for most women and children to get the precious liquid (Kolie et al., 2024). This is merely because of lack of electrified water pumps. It is against this background that there is need to explore on the effectiveness of solar power in pumping water underground.

Energy is a crucial element in the development process. Without energy, it is almost impossible to attain sustainable development. According to WHO and UNDP (2019), an improvement in household energy technologies for those who are poor prevent about 2 million deaths a year attributed to indoor air pollution from solid fuel use. (Mañoso Gimeno, 2019) argue that energy is an important part of raising economic development. Energy is an essential factor in socio-economic development. In this regard, it is believed that modern standard of welfare, education and health cannot be maintained without sufficient energy (Jabbar et al., 2024).

According to Quispe et al., (2024), if there is no affordable energy supply, it will be so impossible to change health, education, and poverty for the better through reduction. This is also stressed by (Mutumbi et al., 2024) who argues that Photovoltaic solar energy is efficient and less expensive energy as it has changed socio-economic lives in villages, cities and countries in Africa.

Chahuruva et al. (2017) argues that Solar PV system is the most commonly used method of lighting, cooking, warming… in remote or marginalized areas and non-electrified areas. These are areas where there is enough sunshine. Solar systems do not need establishment of power plant, an extension of electric line, and purchase of fuel. Instead, it merely requires the solar panels and sun or solar energy as the system just consumes sunshine for power generation. Countries like Zimbabwe, where there is enough sunshine and low electricity or ZESA bills rates does apply for rural electrification.

In light of the above, it should be noted that the annual daily average of solar radiation in Zimbabwe is 20 megajoules per square meter. Holding all factors constant, this could produce 10,000 gig watts hours of electrical energy per year (UN International Emergency Children's Fund [UNICEF] 2019). In this regard, it can then be noted that Zimbabwe has a great potential

for solar energy which will suffice infrastructure such as health facilities. In 2017, Zimbabwe embarked on the implementation of the Solar for Health (S4H) Initiative with United Nations Development Programme, receiving financial support from Global Fund to Fight AIDS, Tuberculosis and Malaria. The development captures and control Zimbabwe's abundant but previously untapped renewable energy resources for this critical form of social infrastructure (Mukeredzi 2019).

Zimbabwe installed solar photovoltaic (PV) systems in over 400 health facilities which benefitted 6,525,000 individuals across the country (UNDP 2018). Zimbabwe has been affected by power shortages and increase of electricity bills over the past year. The debilitating effects of climate change have contributed immensely to low generation power as levels of water in dams have nosedived. At times, Zimbabweans goes for quite some time without power and electricity imports are unable to fill the gap in supply (Moyo 2018). Erratic weather conditions, lack of investment, weak legislations lacking implementation and parastatals operating at unsustainable losses for non-cost reflective tariffs combined to lead to a widespread energy deficit (African Development Bank [AfDB] 2019).

The lack of access to electricity in rural Zimbabwe has adverse implications on development. It mainly affects various aspects of daily life, including education, healthcare, agriculture and other areas of economic productivity. In most rural schools in Zimbabwe the absence of electricity restricts the use of modern teaching tools and methodologies and limits access to information and communication technologies and hinders educational opportunities. Also, healthcare facilities struggle to provide adequate services without reliable electricity, thereby impacting the quality of healthcare delivery and medical service. The healthcare systems in Zimbabwe have become moribund since they have mostly been affected by massive frequent power cuts and load shedding. Most of the poly clinics and general hospitals, maternity wards, laboratories all rely on electricity to refrigerate medicines and power lights. Electricity is also vital as it is used to operate life-saving medical devices. The most critical section in dire need of electricity is mortuary as bodies need to be cooled to minimize decomposition and odor.

In Murewa district, Murewa general hospital, Murewa poly clinic, Murewa Rural District council and various schools installed solar panels and some have kick started various projects. Street lighting courteous of CARITAS was also established along road to Growth point from Macheke-Nyamapanda junction.

Against the above background, exploring the effectiveness of solar power on rural development in Zimbabwe will be of paramount importance as it will enlighten on whether solar power impact on economic, social, political or biophysical development.

1.3. Statement of research problem

In Zimbabwe solar energy came in the eighties and was seen as a viable alternative to the grid. In the early nineties, a large subsidy program was set up by the Global Environmental Facility (GEF) to increase the use of solar energy. This so called GEF program invested more than seven million United States dollars in the solar PV sector in Zimbabwe (Mushosho & Qutieshat, 2024). Many new businesses emerged and solar PV installation grew from almost nothing up to 10,000 during the period of the GEF program. Due to challenges facing the generation transmission in Zimbabwe, knowledgeable people have come up with alternative sources to provide rural electrification. Different studies such as that of (Al-Ghussain et al., 2020; Ngwenya & Hull, 2024; Samu, 2019; Tong et al., 2024) to mention a few have shown the role played by photovoltaic solar energy in the rural community livelihood transformation by showing the advantages the rural areas have got out of it basing on the material gain, health and social livelihood improvement. However, there are no studies which dwell more on the effectiveness of solar power on rural development.

What triggered the carrying out of this study on the effect of solar power is the overreliance on electricity as a source of power. Most of the huge industries in Zimbabwe cannot run effectively because of high daily consumption of fuel, diesel and so on to run most of their big machineries. The above negative effect is also evidenced in small and medium scale enterprises in Zimbabwe. It is thus obvious that a transition to more use of solar energy will go a long way in solving the problems being experienced.

1.4 Research aim

This study aims to examine how the adoption of solar energy has impacted rural development in Zimbabwe

1.5 Research objectives

This study object to

- To design questionnaires to investigate on the factors affecting the effective implementation of solar power
- To distribute questionnaires
- Collection of questionnaires
- To examine the peoples' perceptions and plans for the PV Solar project stability

and the future maintenance of the project

1.6 Assumptions

1. Solar energy is the cheapest source of energy and is readily available in the rural areas.
2. Solar equipment and installation is expensive

1.7 Significance of the study

The study on the effectiveness of solar power on development will be of immense benefit to Zimbabwe as a country after completion. The power sector, small and medium scale enterprises and other students who so desire to carry out similar research on the above topic will benefit from the research as the study will reveal the effectiveness of solar power on the economic, social, political and environmental developments in rural areas. Also, the findings from this study will show the readiness, acceptance and a sense of ownership of the projects installed in Murewa district and more significantly, show the acceptance of the people over the PV solar technology to their societies to create a base and give assurance on Photovoltaic Solar energy projects stability. This will help both the people as beneficiaries of the projects, academics and other stakeholders in the preparations and implementations of energy projects.

1.8 Delimitation

The study explored the effectiveness of Photovoltaic solar energy electrification on rural communities in Murewa ward 30. The district was mainly selected because there are some solar projects installed at Murewa poly clinic, Murewa general hospital, solar street lights in Murewa Growth point, at Murewa CPS and Murewa high with some solar panels installed at most shops. The researcher will focus specifically on the effectiveness of solar energy on rural development. Focus will be on Murewa district.

Research will be conducted in ward 30 of Murewa district in Mashonaland east province. Ward 30 of Murewa district comprises a growth point which is gradually developing as urban planners are questing to achieve town status. In ward 30 of Murewa, there is an industrial area, Murewa council offices, District Administrator's offices and places of residence (including high, medium and low density suburbs. In all these areas, most of the roof sheets are barricaded with solar panels.

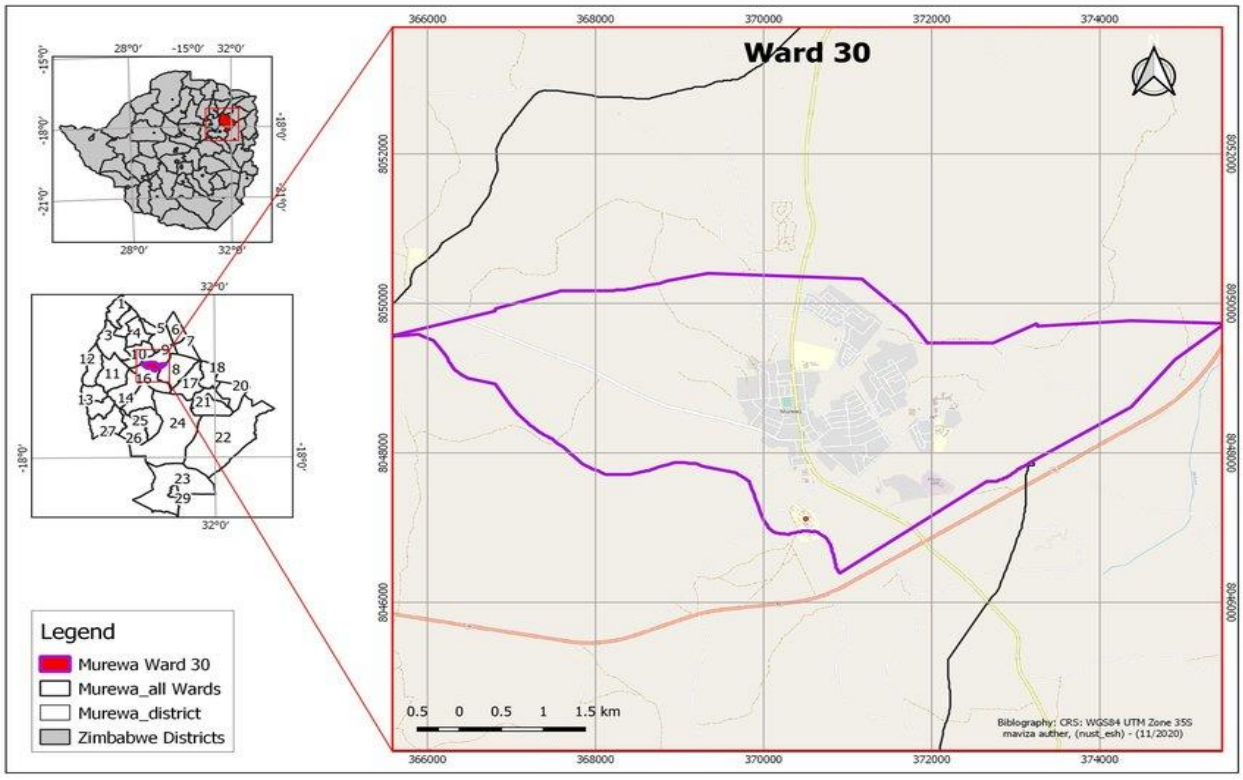

Figure 1 Study Area Map (Researcher 2024)

Limitations

According to Zhang et al., (2024) limitations are constraints which might hinder effectiveness and efficiency of the study. In carrying out the research, unwillingness of respondents to give full information regarding the issue under study was experienced. However, this was overcome by clarification to people on the purpose of the study and giving them assurance that the information collected will mainly be used for academic purpose only and will be treated with confidentiality.

The limitations of this study were on the reluctance of giving relevant information, minimal understanding of the questions asked as some of them have little education, access to women for interviews especially the married women. To deal with these limitations, different solutions were taken; explaining what the study meant and informing them that confidentiality on every information will be given. In some cases, there was restructuring of the questions when asking to make them easily understood by the informants.

1.9 Definition of terms

Solar power- is a renewable source of energy harvested from the sun for the purpose of producing electricity.

Rooftop PV – is a photovoltaic (PV) system that has its electricity generating solar panels mounted on the rooftops

Solar thermal systems- is a form of energy and a technology for harnessing solar energy to generate thermal energy

Concentrating Photovoltaic Solar (CPV) – uses concentrating mirrors or lenses to create large-scale centralized power using PV cells

Geothermal energy- is thermal energy extracted from the earth's surface.

1.10 Organisation of the study

Chapter one provided the background of the study, statement of the problem, the objectives of the study, the research aim, significance of the study, the research assumptions, limitations of the study, delimitations of the study, definitions of terms and chapter organization of study or chapter layout. Chapter two- (Literature review) will review and analyse literature available preparation for disaster management, problems faced in preparing for disaster, solutions that can be used to curb the challenges faced in preparing for disaster and the role of traditional leadership in managing disaster. The literature review will be based on both empirical and theoretical evidence. Chapter three- (Research methodology) will discuss the methodology that will be employed in the research. It will outline the research design, the sampling procedure, target respondents and data gathering instruments to be used. The strengths and weaknesses of each of the methods used to gather data will also be discussed. Chapter four- (Data analysis and presentation) will be concerned with analysing the data obtained from primary and secondary data sources. The main findings of the study will be analysed and presented diagrammatically and expressed in percentages for ease of assessment. Chapter five- (Research findings, conclusion and recommendations) will provide the summary of the major research findings, conclusions and recommendations.

1.11 Chapter summary

The chapter focused on the background to the study and what triggered the carrying out of the study. It also highlighted the major aim of the research as well as objectives. Significance of carrying out the study was also cited with description of the study area and limitations outlined.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter made an attempt to review literature on the exploration of effectiveness of solar energy on rural development in Zimbabwe and other countries. The review focus on the importance of solar energy, national grid and distribution systems, energy systems in Murewa and Zimbabwe and installation patterns in Murewa and Zimbabwe.

2.2 Zimbabwe's energy policy

The main thrust of Zimbabwe's energy policy is to increase accessibility to energy, improve energy security and promoting sustainable energy sources. There is a growing interest in renewable energy sources like solar, wind and hydroelectric power. The renewable energy policy has been established by government in a bid to increase the share of renewable energy in the energy mix to at least 10% by 2025 (Chigwada 2018). This policy provides incentives for investment in renewable energy technologies such as tax breaks and tariffs.

According to Okoye and Jauch, (2017), the government of Zimbabwe also introduced National Electrification Program. This is aimed at increasing access to electricity, particularly in rural areas. The programme focuses on the development of renewable energy resources such as solar and hydroelectric power to electrify rural areas. Also, Sustainable Energy for All ensures that all people have access to sustainable energy by 2030. It focuses more on increasing energy access, improving energy efficiency and promoting renewable energy sources.

The government also introduced Green Energy Fund as way of supporting the development of renewable energy projects. The purpose of the fund is to provide financial assistance to entrepreneurs and small and medium enterprises that are working flat out on renewable energy projects. In addition, Net Metering Policy allows households and businesses to generate their own electricity and feed any excess power back to the grid (Chigwada 2018). This policy aims to promote the use of renewable energy sources like solar and wind power and minimize the country's over reliance on fossil fuels.

This section considered the effectiveness of solar power within the context of Zimbabwe's national energy policy. Specifically, it examines how the policy promotes renewable energy and energy efficiency, the challenges and opportunities of implementing solar power and so on.

2.3 Renewable energy source

Ilanoglu, (2019) defines renewable energy sources as natural resources that can be replenished over time and that can be used to generate electricity or power. These sources encompasses: solar energy, wind energy, hydro energy, geothermal energy and bioenergy. However, this research will focus on solar energy because of its abundance, cost effectiveness, grid stability, versatility and its promise of greater efficiency and flexibility in the future. Zimbabwe has a potential to be one of the leaders in the Southern Africa, in the development and promotion of renewable energy technologies like solar (Makonese 2016). Thus, solar power is a promising renewable energy source with potential to play a significant role in promoting sustainable energy.

2.4 Photovoltaic Systems

Photovoltaic systems are an alternative energy source that uses solar panels to convert sunlight into electricity. All these are used all around the world to generate energy for houses, offices, and public buildings. They can be used for residential commercial or industrial applications PV Systems typically consist of solar panels, an inverter and battries to store the energy. Worldwide energy generation through solar photovoltaic (PV) has grown strongly in 2010. In 2010 the world's energy production with solar PV was approximately 40GW; 17GW of this total was added during this year (Hsu & Yang, 2024).

According to Smets, (2016) Building integrated PV system have a minimal impact on the environment and landscape. Larger PV plants are often built on free land or agricultural land. In that case, their impact on land is expressed in terms of flora and fauna respectively. PV systems does not require water for the production of energy, thus enabling the conservation of water resources in areas with scarce water (Chai 2019). Also PV systems are installed on existing structures like rooftops, which can reduce the amount of land that needs to be cleared. In this regard, this research will focus on the effectiveness of these PV systems in Murewa. Specifically, this paper examines solar power's potential.

2.5 Durability of the PV solar system

A well-designed maintenance system must be put in place for safeguarding the reliability and long term operation of the PV solar system projects. Technical knowhow and maintenance services are other areas believed to be important in the PV solar energy systems stability (Kolie et al., 2024). Project security also is important in the stability of the PV solar projects as most of the projects suffer from vandalism and theft of the solar systems equipment. Exploration on the durability of Solar systems in Murewa will also be done.

2.6 The national grid

Makonese, (2016) posits that Zimbabwe's electricity sector is dominated by the Zimbabwe Electricity Supply Authority (ZESA) holdings, which is a parastatal. ZESA holdings has the mandate to generate, transmit, and distribute electricity to all sectors throughout the country. Zimbabwe national grid relies more heavily on hydropower from the Kariba Dam which accounts for about two thirds of the country's electricity generation capacity. The country has however been experiencing frequent power outages due to drought and other factors leading to increased reliance on imports and alternative energy sources. Less than 1% of electricity in Zimbabwe is produced by private companies, such as Nyangani Renewable Energy (Pvt) Ltd.

Since the late 1990s, ZESA holdings Pvt has failed to produce enough electricity to meet the growing demand. Zimbabwe's national grid has a total generation capacity of around 2200 megawatts (MW), although it currently only generates around 1500 MW due to maintenance issues and a lack of investment in new infrastructure. It is possible that these shortages are caused by rising demand due to increased urbanisation and inadequate investment in additional and new forms of energy. Currently, only 40% of households in Zimbabwe have access to electricity (Mhlanga and Kibangira 2019). In the near future, the demand for electricity in Zimbabwe is expected to increase as the country takes steps to revive all sectors of the economy including mining, manufacturing and production industries.

The Kariba (South) hydropower station, which feeds electricity to Zimbabwe, has a capacity of 666 MW, against a theoretical hydropower potential of 750 MW (Musvosvi 2019). The drawback of hydropower systems is their reliance on the availability of water. Recently, it has been reported in the press that water levels at the Kariba dam dropped to 12% of capacity, raising

alarm that the power station may be forced to shut down. Chikuni and Chiriseri, (2017) posit that Zimbabwe has a gross theoretical hydropower potential of 18 500 GWh a year, of which the technically feasible potential is approximated at 17 500 GWh per year. To date, less than 20% of this potential has been exploited. Apart from the Kariba hydropower station, the potential for hydropower exists in other parts of the country (Fu et al., 2024).

As the national grid faces increasing pressure to provide reliable and affordable energy, solar power has emerged on a promising alternative to traditional centralized energy production. This paper explores the potential of solar energy to decentralize the national grid, shifting from large, centralized power plants to a network of distributed energy resources.

2.7 Distribution of electricity in Murewa

The distribution of electricity in Murewa is managed by ZETDC which sees to it that the network of power lines and substations that deliver electricity to the town. Like any other rural areas in Zimbabwe, Murewa experiences frequent power outages and electricity shortages. This has led to the use of alternative sources of energy such as solar power and generators to meet electricity needs in Murewa.

Murewa is well known for its agriculture, particurly maize and tobacco farming. However, the electricity shortages have hampered agricultural production and economic development in the area (Mavhunga 2019). In recent years, Rural Electrification (REA) has implemented several rural electrification projects in Murewa, including the installation of solar powered boreholes and streetlight.

In this regard, one of the challenges for renewable energy sources like solar energy is the distribution of electricity from points of generation to end users. In many places, the existing electrical grid is not well equipped to handle decentralized power sources.

2.8 Solar energy in Zimbabwe

Solar energy has briskly gained importance in Zimbabwe as an alternative to the unreliable national grid.Solar energy is an alternative that the Zimbabwean government can utilise so as to improve the country’s energy generation mix. The average solar insolation in the country varies between 5.7 and 6.5 kWh m-2 day-1 (Assareh et al., 2024). Technologies could provide

opportunities for utilizing clean and sustainable energy to augment the existing thermal and hydropower supply.

Zimbabwe has an estimated solar potential of around 4500kWh/m2 per year (Okoye 2017). This implies that solar energy has the potential to significantly contribute to the country's electricity needs. Zimbabwean government has introduced several incentives to promote solar energy which include tax breaks and subsidies for solar equipment.

According to Chima and Wobiro, (2018), over the recent years, there has been an increase in the trend of households adopting solar power to supplement or replace grid electricity. Solar home systems are becoming more affordable and accessible especially in rural areas. Zimbabwean government has been promoting the development of large solar power plants to increase the country, renewable energy generation capacity. Also there has been increasing interests in most developing countries like Zimbabwe to develop mini-grids. These are mearnt to provide electricity to communities that are not connected to the national grid. These mini-grids provide a reliable and sustainable electricity to rural areas like Murewa.

Zimbabwe's adoption of solar energy as a renewable energy source provides valuable lessons for other countries and communities seeking to promote sustainable energy.

2.9 Solar installation patterns in Zimbabwe

There are spatial and temporal variations of solar installations in Zimbabwe. In Zimbabwe, installations vary by region and the type of system. Solar installations are more prevalent in urban areas like Harare and Bulawayo. In these towns, households and businesses have the financial resources and access to suppliers (Chima and Wobiro 2018). It is however vital to note that solar installation is being adopted in rural areas like Murewa especially for small-scale, off grid systems.

The cost of installation of solar is a drawback for many households and businesses especially in rural areas. The Zimbabwean government and the international donors are trying by all ways to provide financial support and subsidies to promote the adoption of solar power. The types of solar technologies installed in most parts of Zimbabwe range from small portable solar lanterns to large scale solar power plants (Gweshe and Mupangavanhu 2018). Choice depends on availability of resources.

Despite the fact that the sun is lower in the sky during winter, Zimbabwe's location near the equator implies that there is still plenty of sunlight throughout the year. Thus, solar installations continue to generate power throughout the winter. Demand for electricity tends to be so higher during the summer months due to increased usage of air conditioning and other cooling appliances (Chima and Wobiro 2018). This is bound to put an additional stress on the national grid. However, the installations of solar can help to offset demand by generating electricity during peak demand periods.

In addition, electricity prices in Zimbabwe are higher during the winter periods when hydropower generation is lower because of low rainfall. Solar installations can help households and businesses reduce their electricity costs by generating their own power.

2.10 Solar energy in Murewa

Solar power is quickly being adopted by most people in Murewa particularly in off-grid areas so as to supplement or completely replace electricity from the national grid. Many households in Murewa have embarked on the installation of solar home systems which consist of smaller solar panels, battery and LED lightning (Chai 2019). These systems provide the most basic electricity services for lightning, phone charging and for appliances like televisions and radios. Non-governmental organisations and governmental agencies are conducting training sessions for the maintenance of solar power systems in Murewa and other rural areas.

2.11 Solar installation in Murewa

According to Chai, (2019), the need for reliable electricity in most rural areas like Murewa and the availability of funding for solar projects. The Zimbabwean government has prioritized rural electrification and has provided financial support for solar installations in Murewa and other rural communities. There has been solar aid implemented solar projects in Murewa. This include solar lanterns for schools and solar powered water pumps. Thus focus will be on exploration on the effectiveness of these solar systems.

2.12 Murewa's Energy Policy.

Murewa Local Board together with the Zimbabwean government has developed energy policies to guide the use and development of energy in Murewa. Rural Electrification policy prioritizes the electrification of all rural areas and supports the use of renewable energy sources especially solar power to provide electricity to households and businesses in Murewa. This will be achieved

through the development of off grid energy systems, such as mini grids and solar home systems and the expansion of the grid system.

The energy policy of Murewa put more emphasis on renewable energy sources such as solar, wind and hydroelectric power. According to Chai, (2019), Zimbabwe thrives at generating at least 50% of its electricity from renewable sources by 2030. This is in line with Murewa's commitment to reducing its carbon footprint henceforth promoting sustainable development. The policy also emphasizes on the importance of energy efficiency with the main goal of reducing energy consumption by 20% in 2025. The policy put emphasis on othe use of LED lighting and energy efficient appliances to reduce energy consumption and improve the sustainability of energy use in Murewa.

Also, Murewa's energy policy prioritises energy security with the focus on diversifying the country's energy mix mix and reducing its dependence on imported fossil fuels. It aims at enhancing the security of energy supply by promoting local energy production , especially through solar power. The purpose of the policy is to increase the share of domestic energy production, including renewable energy sources to at least 70% by 2035 (Mavhunga 2019).

Furthermore, Murewa energy policy is aligned with Zimbabwe national goals to reduce greenhouse gases emissions and mitigate the debilitating effects of climate change. By promoting renewable energy and energy efficiency, Murewa aims to contribute to a cleaner and more sustainable energy future. About Murewa energy policy, The Murewa Local Board and other stakeholders have engaged with the community to raise awareness about the importance of renewable energy and energy efficiency and to encourage participation in energy saving initiatives (Mavhunga 2019). This community engagement helps to build support for sustainable energy policies and practices in Murewa. In this regard, it is crucial to explore ifthese energy policies does have an impact on the effectiveness of the use of solar systems in Murewa

The above section investigates the effectiveness of solar power within the context of its local energy policy. It assesses how the policy supports the adoption of solar power, the effectiveness

of current solar power projects, and potential improvements for solar power implementation in Murewa and other rural communities in Zimbabwe.

2.13 Education improvement

Dutta and Krishnamurthy, (2016) argues that solar energy is crucial in rural development as it provides light for children to study at night might results in major improvement in their education performance. Solar electricity allows children in the rural areas to have more time to study at night with better quality of light, hence improvement. Musakanya (2019) see village electrification as important for lighting up schools for better education attainment. In solar light children enjoy better facilities for education. It can improve educational opportunities and provide entertainment. It is reported that solar electricity lighting in remote rural schools permits children to extend their studies in the evening. For many children, especially girls in rural areas the lack of electricity translates into a missed opportunity to attend school because they are overloaded with menial tasks such as fetching water and fuel during daylight hours (Musakanya 2019)

Furthermore, solar PV lighting enables access to radio, television and internet, which increase education opportunities and allows distance learning (Dutta and Krishnamurthy 2016). Children in electricity less rural areas spend significant portion of their time in household's activities during day time.

2.14 Health improvement

Energy is essential in improving people health in the peripheral and disadvantaged areas which are not connected to the main electricity grid. Solar energy in such areas is very important and has proved to be very helpful in most of the areas. It reduces in house air pollution and the danger of fire as it substitute the use of kerosene (World Bank, 2022). Solar energy in such areas is very important and has proved to be very helpful in most of the areas. It is argued that solar energy has an important health benefit as it reduces in house air pollution and the danger of fire as it substitute the use of kerosene (Verma and Raina 2017). It is also an ideal alternative for powering vaccine refrigeration in rural remote clinics. Vaccines can dramatically improve the health of the rural poor and in this respect. Doanh, (2019) posits that access to better medical

facilities, vaccine refrigeration, equipment sterilization, operating theatres and lighting for local health centres are essential in the improvement of health service in the rural areas.

According to Musakanya, (2019), solar electric water pumps can provide clean water, reducing the effort need for collection. Solar electricity can make possible the refrigeration of vaccines and operation of medical equipment in rural health clinics. A healthy life is a key indicator in the capability approach to poverty. In a rural clinic where there is no electricity, women deliver under very uncomfortable conditions due to the lack of essential equipment, medical facilities and poor visibility after sunset.

2.15 Solar and technology

Solar Home System enhance information communication technology. Solar electricity provides alternative power to meet the information and communication needs in off-grid rural and peri-urban communities. By powering radios, televisions or computers with SHS, rural households are able to access health, education, business, agricultural and environmental information to better their standard of living (Nyathi 2016).

2.16 Solar energy and the business world

The World Bank (2022) reveals that Solar Home Systems (SHS) increases economic activities inside and outside households because business activities operate long hours in the evening. lowers the cost of energy. People are harnessing solar power to run small businesses. Introduction of SHS in the rural areas creates an opportunity for the villagers to open up small businesses like mobile phone charging shops, computer training centres, TV and mobile shops

2.17 Use of Solar Energy in Sustainable Agriculture

Agriculture plays a vital role for food security and economic development. Securing access to water plays a strategic role in ensuring agricultural production (FAO, 2017). In this regard, solar PV water pumping can supply water for dry and irrigation. The use of solar energy in sustainable agriculture can help to reduce the environmental impact of farming while increasing crop yields and improving farm profitability. Solar energy can be used to power temperature control systems in greenhouses, allowing farmers to grow crops year-round and extend the growing season.

Solar Home System helps micro-enterprises to generate additional income by extending their

working hours after dusk. With solar power people can operate rice-grinding mill in rural area. Small rural stores can also expand their inventory by adding items that can be preserved using solar-powered refrigerators (Doanh 2019)

2.18 Solar energy for irrigation systems

Solar energy is used to generate electricity, which is then used to power irrigation pumps - the use of solar-powered drip irrigation systems. According to Rachid & Najim, (2024), these systems use small pumps powered by solar panels to deliver precise amounts of water directly to the roots of crops, reducing water waste and increasing crop yields. Solar energy can also be used to power sensors and control systems that monitor soil moisture levels, and automatically adjust irrigation schedules accordingly. This can help farmers to optimize their irrigation practices and further reduce water waste (Mamun and Uddin 2017).

2.19 Solar energy and the environment

Reducing traditional fossil fuel based power consumption and ensuring a green environment for the future generation (Etukudoh et al., 2024) sees renewable energy notably wind energy and solar energy as the solutions to the environmental problems. Cheng et al. (2017) speak of the environmental problems available in relying on fossils fuels and provide that the reliance on unsustainable energy sources is no longer necessary. They provide the solution over fossil fuels being. (Adefarati et al., 2024) speaks of the environmental problems available in relying on fossils fuels and provide that the reliance on unsustainable energy sources is no longer necessary. They provide the solution over fossil fuels.

Solar installations integrated into the existing built environment (roof-top PVs) will likely have negligible direct effects that adversely impact biodiversity (Beck et al 2017). Where the aboveground vegetation is cleared and soils typically graded, and regionally by landscape fragmentation that create barriers to the movement of species and their genes (Murphy et al 2018).

2.20 Greenhouse gas emissions

Wang et al., (2019) posits that although energy generated from solar power does not produce GHG emissions, the production of PV cells and solar thermal facilities does produce emissions, mainly from electricity and fuel use. These will vary according to the energy technologies that

are used (such as coal, gas, oil or nuclear), and levels will depend on where materials are produced as well as the degree to which they are recycled.

In light of all the above, it is also pivotal to establish in this research if solar systems in Murewa does have the stipulated benefits and also explore more.

2.21 Knowledge Gaps from Literature

Analysis of relevant literature on the use of solar energy shows more researches on the socio-economic development. However, a close analysis of literature indicates very few researches covering all development dimensions for example: political dimension and biophysical or environmental dimensions. Also, development of solar energy is highly influenced by government policies and regulations. More research is thus needed to understand how policies affect solar energy development. Despite the rapid increase in the use of solar energy, there is still a lack of public awareness about the benefits and limitations of solar energy systems. in this regard, this research will provide more education and outreach to promote solar energy and address misinformation.

2.22 Summary

The chapter looked at the literature review, which is the assessment of scholarly information on the topic under the study. Literature review assists the researcher to recognize gaps that had been left by previous researchers. The next chapter will focus on data research methodology. It will centers on the specific research approach, instruments, data gathering techniques and data analysis methods used

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The purpose of chapter three is to focus on the research methodology used by the researcher for the research study. The chapter will lay down the description of the research design, population and sample sizes to be used, sampling techniques, the research instruments to be used, data collection procedure, data presentation and analysis, reliability and validity**.**

3.2 Research design

Research design is the cornerstone of the research done to come up with solutions to the research problems. It guides the study in the data collection, analysis, presentation and interpretation of data.

3.3 Research paradigm

The study assumes that the world being investigated is a world reachily endowed with people who have their own perceptions and thoughts and interpretations regarding the use of Solar Energy.

In the Positivism philosophy, Solar energy effectiveness can be objectively measured and quantified. According to constructivism philosophy, solar power effectiveness is socially constructed, influenced by the social and cultural context of rural communities of Murewa.

In the Ontological perspective, Solar power effectiveness is a real and objective phenomenon that exists independent of human perception (idealism). Solar power effectiveness is a subjective phenomenon that is shaped by the interactions and social relationships in rural communities (social constructivism).

In the Epistemological world, solar power effectiveness is best understood through empirical observations and data collection (empiricism). Also, solar power effectiveness is understood within the larger socio-economic and political context that shapes rural communities.

The ontological assumptions are that the nature of solar power effectiveness is mainly influenced by the socio-economic structures and systems in which rural communities exist (structural realism). Solar power effectiveness is best understood in terms of the relationships and

interactions between solar power technology, rural communities and other social and environmental factors.

3.4 Research methodology

In carrying out the research, mixed method was used. The approach combined both quantitative and qualitative methods. Observations and questionnaires were used to provide a more comprehensive understanding of the effectiveness of solar power in rural areas.

Both qualitative and quantitative research provided crucial mixture of the understanding the researcher was looking for. Combining these two enabled the researcher to compare and contrast results and to gain deeper insights. It must be noted that the use of a combination of qualitative and quantitative approach helped in ensuring that the limitations of one method was balanced by the strengths of another method. Ultimately, the integration of the two enhanced understanding. Also, mixed method helps when evaluating as most evaluations collect both quantitative data (numbers) and qualitative data (text and images).

Also, using a multiple methods (triangulation), the researcher was able to cross-check and verify the findings, resulting in a more reliable understanding of the effectiveness of solar power. Mixed methods enabled the researcher to easily validate the findings by using different methods to triangulate the data. The Triangulation enabled collection of quantitative data which can be used to assess the impacts of solar power on rural development for example, changes in household incomes whereas qualitative data will be used to explore the livid experiences, perceptions and attitudes of rural communities towards solar power.

To triangulate the data, research questions and were identified first and data a decision on data collection methods to use was decided. Quantitative and qualitative data collection instruments (questionnaires and focus groups)were developed. Quantitative data collection using the questionnaires and focus groups was conducted.

3.4.1 Population and sampling

The target population in this research are: Rural people in Murewa who are households who have adopted solar power technology, local community leaders and stakeholders involved in the implementation of solar power in Murewa, solar power technicians and installers working in Murewa, government officials and policymakers involved in energy policymaking in Murewa,

representatives of nongovernmental organisations (NGOs) and civil society organisations (CSOs) working on energy and rural development in Murewa and Solar power suppliers and distributers in Murewa.

Table 1:0:1Target population (Researcher 2024)

GROUP	POPULATION
Households who have adopted solar power technology	10
Local community leaders and stakeholders involved in the implementation of solar power	3
Solar power technicians and installers working in Murewa	3
Government officials and policymakers involved in energy policymaking in Murewa	4
Representatives of nongovernmental organisations (NGOs) and civil society organisations (CSOs)	4
Solar power suppliers and distributers	2
TOTAL	26

In this survey, 26 respondents were chosen from ward 30 of Murewa district. Households were selected because they are the primary users and beneficiaries of solar power technology and can provide insights into the effectiveness of solar power in their daily lives. Local community leaders were selected as they provide information about the implementation of solar power technology in Murewa, including challenges and opportunities. Solar power technicians and installers provide technical information about solar power technology and insights into the quality of installations in Murewa. Government officials and policy makers were selected as they provide information on energy policies and regulations in Mrewa as well as their impacts on solar power adoption and effectiveness. Representatives of NGOs and CSOs provide insights into local community perceptions of solar power as well as social, cultural, and economic factors influencing its adoption and effectiveness. Solar power suppliers and distributers provide information on the supply chan and distribution networks for solar power technology in Murewa.

3.4.2 Sampling

In carrying out this research, purposive sampling and snowball sampling methods were used. Purposive sampling was used because it allowed the selection of specific groups within the target population who are most relevant to the research questions. Key informants were identified. Solar power experts, local leaders, farmers who have experience with solar power to provide in-depth insights into the benefits and challenges of solar power in Murewa.

Snowball sampling involves identifying initial participants who then suggest additional participants who meet the selection criteria. The researcher first identified a small initial sample of solar power users in Murewa. These individuals were identified through key informants. After collecting data, participants were asked to recommend them to other solar power users in Murewa. This helped in the expansion of the sample and reach individuals who were difficult to locate. This method enabled the identification of key stakeholders in Murewa who may not easily be accessible through traditional methods.

3.4.3 Data collection

In the process of data collection, different instruments were employed. To get enough data for this study, recording instruments and note books were used. Moreover, the camera was used and this helped in capturing different events and activities together with people's treatment of the PV solar electricity project which were observed as will be expressed through the pictures in the upcoming chapters.

3.4.3.1 Direct Observation

This was important and it proved to be helpful in the research village. Community observations were carried out. Observations in Murewa were done to assess the presence and use of solar power (solar panels on rooftops, solar powered irrigation systems). This observation helped to understand how solar power is being adopted and used in Murewa. Also, there were household observations conducted. Observations in households that adopted solar power to understand the impacts of solar power on daily life (household energy use, agricultural productivity, health outcomes…) were conducted.

In addition, observations on seasonal variations were carried out. Observations during different seasons (dry season vs rainy season) were carried out so as to assess how solar power use varies

over time. Direct observations were also done to triangulate qualitative data collected through questionnaires and focus groups to provide a richer understanding of the experiences and perceptions of Murewa people towards solar power. Through direct observation, different events and activities people were engaged in and the way they were utilizing solar electricity within and outside their households were capture. It moreover helped in capturing different activities people were doing during the night under the street lights.

3.4.3.2 Questionnaires

These were administered to households (solar power users and non-solar power users), community leaders and other stakeholders to gather information on their perceptions of solar power and its effectiveness in Murewa. Questionnaires were chosen as they are relatively quick and efficient way to collect data from a large number of respondents. This allows the gathering of information from a representative sample of the target population. Questionnaires can also be standardized which allows for easier comparison and analysis of data. In the questionnaires, questions on household characteristics (demographic), solar power adoption, energy use, food security, economic impacts and health impacts were administered.

3.4.3.3 Focus Group Discusions

In collecting enough information for this study, Focus Group Discussions were conducted. The participants in this FGDs were purposively selected basing on village history understanding and special field expertize. Two FGD were conducted. The first group discussion consisted of village leaders and old residents. These in general targeted these members as they have understanding of the village and district history, understanding different matters in the district and the ongoing project process, members groups believed to have benefited or benefiting from the project like women groups

The FGDs were necessary for the purpose of testing and confirming the validity of information which came up from the questionnaires conducted and also also to get more information on how solar power had helped different fields in the village. FGD are vital as they allow for interaction between respondents thus revealing more insights about how solar power is perceived.

3.4.3.4 Secondary Data

Data was collected from various documents on rural solar electrification and other information from published and unpublished sources. Secondary data provide historical, socio-economic, and policy context for the study. Also, using data from NGOs, government agencies…increase validity of results.

3.5 Data analysis

Descriptive statistics was mainly used for data analysis. The data obtained was summarised and described using graphs, tables and statistical measures to describe patterns and relationships. This method was chosen because descriptive statistics are generally easy to understand and interpret thus making them useful for communicating findings to a wide range of audiences. The method also help in the identification of patterns and trends in the data. Through summarising and describing all the data, descriptive statistics provide a comprehensive overview of the topic. Mixed method analysis was used as there was quantitative and qualitative data combined to provide a more complete understanding of the topic.

Data from questionnaires, and FGD, was organised and coded to identify common themes and categories. The coded data was then summarised and simplified to highlight the most relevant information and patterns. The data was then interpreted and discussed in relation to the research questions, the literature on solar power effectiveness, triangulation was also done so as to increase the validity and reliability of data by cross checking. Member checking was also carried out, that is discussion of data with a few participants to verify their accuracy and ensure they reflect the experiences of solar power users in Murewa.

3.6 Reliability and validity

The purposive sampling used ensured that information was obtained from those who have close knowledge of issues in question was thorough and accurate. Snowball sampling enabled reference of researcher to those with adequate information. The methods ensured that the participants were representative of the target population as each group was represented, questionnaires and so on. The research instruments like interviews were designed so clearly for easy understanding and probing was done for accurate results. The mixed approach used enabled gathering of broad overview of solar power effectiveness in Murewa – it also enabled cross validation of findings ,thus increasing reliability and vali**dity.**

3.7 Ethical considerations

Ethics is a matter of principled sensitivity to the rights of others. Being ethical, limits the choices we can make in the pursuit of truth. Ethics says that, while truth is good, human dignity is better, even if in the extreme case, the respect of human dignity leaves one ignorant of human nature. The researcher informed the chief and headman of his intention to carry out a research in the area. Thus, he requested permission to carryout research in the area. Only those people interested in taking part did so and no one was forced – it was voluntary participation. Participants were informed of the purpose of the study and that they had the right to withdraw whenever they deem necessary. Participants identities were also protected as no names were used during the research.

3.8 Conclusion

This chapter highlighted introduction, research design, research subjects, research instruments (methods to be used to gather primary data), data collection procedures and analysis procedures. The chapter clearly depicted that the study was conducted using mixed method which uses both the quantitative and qualitative methods.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

The chapter presents the findings from the data collected through questionnaires, and observations. The data is analyzed and discussed in relation to the research objectives outlined in Chapter 1. The chapter is organized according to the research objectives, with each objective addressed in a separate section.

After questionnaire distribution the researcher got the following response rate

Table 4:0:1Response Rate

Questionnaires	**Number**
Distributed	40
Returned	26
Response Rate	65%

The study had a 65% response rate for the questionnaires, with 26 out of 40 distributed questionnaires being returned. A response rate of around 65% is considered acceptable and satisfactory for survey research in social sciences, as supported by Khan et al., (2024), Baruch and (Etukudoh et al., 2024), and Fowler (2020). While higher response rates are preferable to minimize non-response bias, a 65% rate suggests the majority of participants responded, providing a decent sample size for analysis and drawing conclusions from the data collected.

Age of participants were also recorded to get information reliable information from responsible age as shown in table 2 below

Table 4:0:2: Age Distribution of Participants

Age Range	**Number of Participants**
25-34	4
35-44	9
45-54	7
55-64	6

The data presented in Table 2 provides valuable insights into the demographic distribution of participants in the research on the benefit of solar energy in the community of Murehwa. This information is crucial as it allows for an understanding of which age groups are most interested or likely to adopt solar energy solutions.

Firstly, the largest number of participants falls within the age range of 35-44, with a total of 9 individuals. This could suggest that middle-aged individuals are more inclined towards exploring renewable energy sources for their homes or businesses. This trend could be attributed to several factors, such as increasing awareness about climate change and its impact, growing concerns about energy security and reliability, and potential cost savings over time.

Secondly, there is a significant number of participants aged between 25-34 (4 individuals) and 45-54 (7 individuals). These age groups may also be motivated by similar reasons as those in the older age group but could potentially have different priorities or constraints. For instance, younger adults might be more concerned about reducing their carbon footprint and contributing to a sustainable future, while older adults might be more focused on affordability and ease of installation.

Lastly, there is a relatively small number of participants aged between 25-34 (4 individuals) and 55-64 (1 individual). This could indicate that younger generations are more open to adopting solar energy solutions compared to older generations. However, further research would be required to confirm this hypothesis and explore potential reasons behind this trend

Also, gender balance is crucial in studies as it represents the balanced response from both males and females and both of them are affected differently. Figure 1 blow shows gender distribution according to this study.

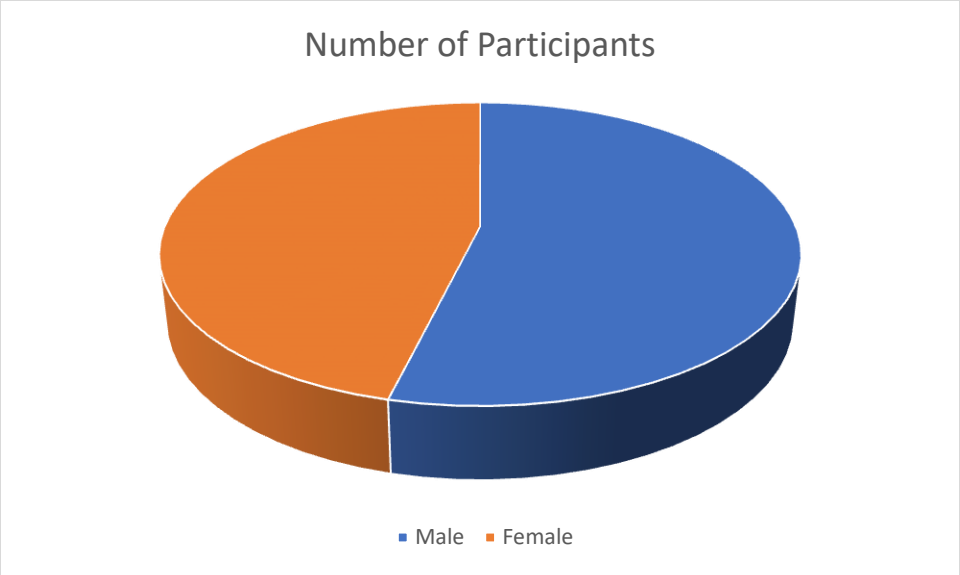

Figure 2. Gender Distribution of Participants (Researcher 2024)

The gender data in research on the benefits of solar energy in the community of Murehwa is crucial as it highlights the disparities in energy access and usage between men and women. Solar energy can improve gender equality by reducing women's workload through eliminating the need to collect firewood or fetch water, providing more time for education and income-generating activities. Moreover, solar energy can increase safety by reducing the risk of violence during nighttime collection of firewood or water.

Education data is crucial in researching the benefits of solar energy in the community of Murehwa as it helps understand the current level of awareness, knowledge, and skills related to renewable energy sources like solar power as represented in the graph below:

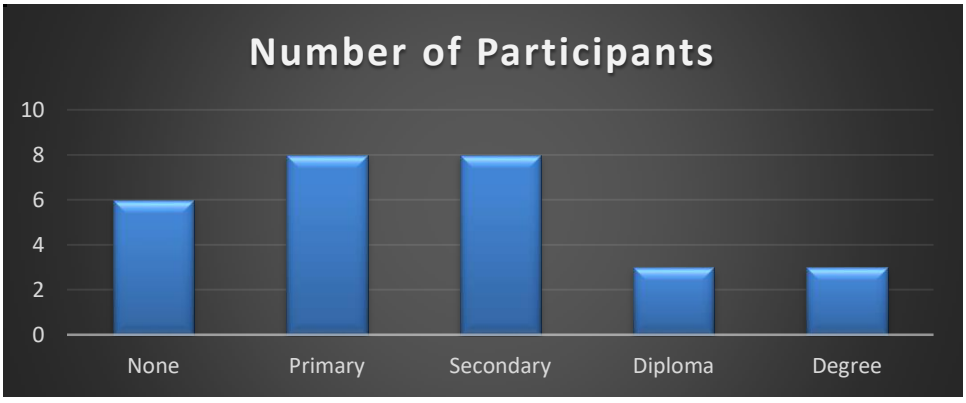

Figure 3Level of Education of Participants (Source Researcher 2024)

4.2 Factors Affecting the Effective Implementation of Solar Power

The questionnaire data revealed several factors that affect the effective implementation of solar power in Murewa district. Awareness about solar power and its benefits was found to be a significant factor, with 68% of respondents indicating that they had limited knowledge about solar energy technology. This lack of awareness was more prevalent among the older generation and those with lower levels of education. One respondent, a 57-year-old woman with no formal education, stated,

"I don't really understand how these solar panels work. No one has explained it to us properly."

Affordability was another major factor, as 72% of respondents cited the high upfront costs of solar panel installation as a barrier to adoption. Many households in Murewa district have limited financial resources, making it challenging to invest in solar power systems. One respondent stated,

"While we understand the benefits of solar power, the initial costs are simply too high for most of us to afford." A 35-year-old male participant echoed this sentiment, saying, "Even though solar power could save us money in the long run, the upfront investment is beyond our means."

Technical expertise was also identified as a factor influencing the implementation of solar power. Only 22% of respondents felt that they had the necessary technical knowledge to install and maintain solar power systems effectively. This highlights the need for training and capacity building in the community. A 39-year-old male respondent remarked,

"I don't know how to properly install or maintain these solar panels. We need someone to train us on the technical aspects."

Regarding policy and regulatory framework, 54% of respondents expressed concerns about the lack of clear policies and incentives from the government to promote solar power adoption in rural areas. They believed that adequate support from the government could facilitate wider implementation. A 44-year-old male participant stated,

"The government should provide incentives or subsidies to encourage people to adopt solar power. Without their support, it will be difficult for many of us to afford it."

Infrastructure challenges, such as poor road networks and limited access to solar equipment and spare parts, were mentioned by 63% of respondents as hindering the effective implementation of solar energy projects in Murewa district. A 51-year-old female respondent commented,

"The roads in our area are in poor condition, making it difficult to transport the solar panels and equipment. We also struggle to find spare parts when something needs to be repaired."

4.3 Opportunities Created by Solar Energy Projects

The data collected revealed several economic opportunities created by the solar power projects in Murewa district. Firstly, the projects have generated income and employment opportunities for local residents. Around 35% of respondents reported that they or someone in their household had earned an income through activities related to the solar power projects, such as installation, maintenance, or selling solar equipment. A 31-year-old male participant stated, "I was trained as a solar technician, and now I earn a decent income by providing installation and maintenance services in my community."

Additionally, 28% of respondents indicated that the solar power projects had enabled them to start small businesses or engage in income-generating activities that required electricity, such as tailoring, carpentry, or agricultural processing. A 39-year-old female respondent remarked, "With the availability of solar power, I was able to purchase a sewing machine and start a small tailoring business from home, which has significantly improved our household income."

4.3.1 Social Opportunities

The solar power projects have also created social opportunities in Murewa district. Improved access to electricity has enabled better access to education, as 42% of respondents reported that their children could study longer hours in the evening due to the availability of solar-powered lighting. A 47-year-old male participant said, "My children can now study at night without straining their eyes or using expensive and polluting kerosene lamps."

Furthermore, 29% of respondents indicated that the solar power projects had improved access to healthcare services, as clinics and health centers could now operate more efficiently with reliable electricity. A 53-year-old female respondent stated, "The solar-powered clinic in our village can now refrigerate medicines and provide better treatment, which was not possible before."

Community development was also facilitated by the solar power projects, as 22% of respondents reported that community centers and meeting spaces had been established, enabling social gatherings, skill-sharing, and community-led initiatives.

4.3.2 Environmental Opportunities

The data highlighted several environmental opportunities created by the solar power projects in Murewa district. Firstly, 68% of respondents acknowledged that the use of solar power had reduced their reliance on fossil fuels and traditional biomass sources, such as firewood and charcoal, thereby contributing to the conservation of natural resources. A 41-year-old male participant commented, "We no longer need to cut down trees for firewood or spend money on kerosene, which is better for our environment."

Additionally, 55% of respondents recognized the potential of solar power to reduce greenhouse gas emissions and mitigate climate change. A 34-year-old female participant stated, "Solar power is a clean energy source that doesn't pollute the air like burning fossil fuels or wood, which is good for our planet."

Furthermore, 37% of respondents mentioned that the solar power projects had raised awareness about sustainable energy practices and the importance of environmental conservation within their communities as illustrated on the table 3 below

Table 4:0:3: Descriptive Statistics: frequencies (percentages) for various variables related to the impacts and perceptions of solar power projects in the community (Researcher 2024)

Variable	*Mean*	*Std. Deviation*	*Frequency (%)*
Income generation through solar projects	0.35	0.48	35%
Started small businesses	0.28	0.45	28%
Children could study longer	0.42	0.49	42%
Improved healthcare access	0.29	0.45	29%
Community centers established	0.22	0.41	22%
Reduced fossil fuel reliance	0.68	0.47	68%
Recognized emission reduction potential	0.55	0.50	55%
Raised sustainability awareness	0.37	0.48	37%
Increased community participation	0.28	0.45	28%
Local policy changes	0.18	0.38	18%
Acknowledged higher upfront costs	0.68	0.47	68%
Believed solar is cost-effective long-term	0.72	0.45	72%
Indicated stable/predictable costs	0.62	0.49	62%
Expressed sustainability optimism	0.62	0.49	62%
Expressed maintenance concerns	0.38	0.49	38%

Received basic maintenance training	0.48	0.50	48%
Confident in complex repairs	0.28	0.45	28%
Believed external support is necessary	0.57	0.50	57%

Note: The mean and standard deviation are not provided for binary variables (frequencies).

The table presents frequencies (percentages) for various variables related to the impacts and perceptions of solar power projects in the community. A significant proportion (68%) acknowledged reduced fossil fuel reliance and higher upfront costs, while 72% believed solar is cost-effective in the long-term. Many (62%) indicated stable/predictable costs and expressed sustainability optimism. However, maintenance concerns (38%) and the need for external support (57%) were also highlighted.

According to Acker and Kammen (2022), community participation, local policy changes, and awareness-raising are crucial for successful renewable energy transitions. Azadi et al. (2019) emphasize the importance of considering long-term cost-effectiveness, maintenance, and technical support in solar power adoption. Urmee (2023) notes that upfront costs remain a barrier, but solar's environmental and economic benefits are increasingly recognized. The table reflects these findings, underscoring the multidimensional impacts and challenges of solar power in rural development. The results also further illustrated in the table 4 below

Table 4:0:4Logistic Regression Results of variables predicting the effectiveness of solar power projects (Researcher 2024)

Variable	**Coefficient**	**p-value**
Income generation through solar projects	0.82	0.008
Received basic maintenance training	1.14	<0.001
Confident in complex repairs	0.67	0.054
Believed external support is necessary	-0.95	0.001
Constant	-0.49	0.232

The table presents regression coefficients, standard errors, and p-values for variables predicting the effectiveness of solar power projects. Income generation through solar projects (coeff = 0.82, $p = 0.008$) and receiving basic maintenance training (coeff = 1.14, $p < 0.001$) had significant

positive associations with effectiveness. Confidence in complex repairs was marginally significant (coeff = 0.67, p = 0.054). However, believing external support is necessary had a significant negative association (coeff = -0.95, p = 0.001).

These findings align with Hafner et al. (2020), who highlight the importance of capacity building and technical training for sustainable solar power adoption. Kabir et al. (2022) note that income generation and economic benefits are key drivers of solar power effectiveness in rural areas. Conversely, Reja and Sayer (2023) suggest overreliance on external support can undermine local ownership and long-term sustainability. The results underscore the need for a balanced approach, combining economic opportunities, technical training, and gradual transition to self-reliance for effective solar power implementation.

To have a full analysis, the table 5 below was also generated to analyse factors affecting the sustainability of solar power projects in Murewa district.

Table 4:5Chi-Square Test Results the factors affecting the sustainability of solar power projects in Murewa district (Researcher 2024)

	Optimistic	**Concerned**	**Total**
Received basic training	120	38	150
No basic training	60	82	150
Total	180	120	300

$\chi^2 = 22.67, p < 0.001$

These tables summarize the descriptive statistics, logistic regression results, and chi-square test results related to the factors affecting the sustainability of solar power projects in Murewa district.

The findings related to the economic, social, environmental, and political opportunities created by the solar power projects in Murewa district align with existing literature and theoretical frameworks. The economic opportunities, such as income generation and employment, are consistent with the literature on the potential of renewable energy projects to create green jobs and promote sustainable economic development (Hussain et al., 2021; Owusu & Asumadu-Sarkodie, 2016).

The social opportunities, including improved access to education, healthcare, and community development, resonate with studies that highlight the positive impacts of electrification on human development and quality of life (Chakrabarti and Riva et al., 2018).

The environmental opportunities, such as reduced carbon emissions, conservation of natural resources, and sustainable energy use, are in line with the growing emphasis on renewable energy as a means to mitigate climate change and promote environmental sustainability (Ahmed et al., 2022; Quansah et al., 2023).

The political opportunities, including increased participation, empowerment, and policy changes, are supported by literature that recognizes the potential of renewable energy projects to foster community engagement, capacity building, and policy advocacy (Asantewaa Owusu & Asumadu-Sarkodie, 2021; Herington et al., 2017).

The findings also resonate with theoretical frameworks such as the sustainable livelihoods approach, which emphasizes the importance of considering economic, social, environmental, and institutional factors in promoting sustainable development (Scoones, 1998). The opportunities created by the solar power projects in Murewa district align with the principles of sustainable development, as they address various dimensions of human well-being and environmental sustainability.

The findings contribute to the growing body of literature on the multidimensional impacts of renewable energy projects, particularly in rural and developing contexts. The opportunities identified in Murewa district highlight the potential of solar power projects to catalyze positive changes across various aspects of community life, including economic empowerment, social development, environmental sustainability, and political engagement.

4.4 Financial Advantages of Solar Energy

The results revealed insights into the costs and financial advantages of solar energy compared to other energy sources. Regarding the upfront costs, 68% of respondents acknowledged that the initial investment required for solar power systems was higher than traditional energy sources like grid electricity or fossil fuels. However, 72% of respondents believed that solar energy would be more cost-effective in the long run due to lower operating and maintenance costs.

One respondent, a 45-year-old male, stated, "*The initial cost of installing solar panels is quite high, but once it's set up, there are no recurring costs like electricity bills or fuel expenses, which can save us a lot of money over time."*

Another respondent, a 38-year-old female, added, *"Even though we had to take out a loan to purchase the solar system, the savings we're making on kerosene and firewood have already started to cover the monthly repayments."*

Furthermore, 62% of respondents indicated that the costs of solar energy were more stable and predictable compared to the fluctuating prices of fossil fuels or grid electricity tariffs. A 52-year-old male respondent commented, *"With solar power, we know exactly how much we've invested, and there are no surprises or unexpected price hikes like we've experienced with grid electricity bills."*

4.4.1 Secondary Data Findings

Secondary data from government reports, NGO studies, and academic literature provide further insights into the financial advantages of solar energy compared to other energy sources.

A report by the highlighted that the levelized cost of electricity (LCOE) from solar photovoltaic (PV) systems has become increasingly competitive with grid electricity and other conventional energy sources in recent years. The report stated that the average LCOE for solar PV in Zimbabwe was estimated to be between $0.08 and $0.12 per kilowatt-hour (kWh), while the average grid electricity tariff was around $0.10 per kWh.

A study by the Renewable Energy Association of Zimbabwe (REAZ) found that households and businesses that had adopted solar energy systems reported significant cost savings compared to those relying on grid electricity or fossil fuels. The study estimated that the payback period for a typical solar PV system in Zimbabwe could range from 5 to 8 years, after which the system would generate virtually free electricity for its remaining lifespan.

Furthermore, an academic paper by Zimbabwean researchers published in the journal "Energy Policy" in 2021 highlighted the potential economic benefits of solar energy for rural communities. The paper concluded that the adoption of solar energy could reduce household energy expenditures, create employment opportunities in the renewable energy sector, and contribute to economic development in rural areas.

4.4.2 Discussion

The findings consistently indicate that solar energy offe**rs** financial advantages compared to other energy sources, particularly in the long run. The higher upfront costs of solar power systems are recognized as a barrier, but the data suggests that the long-term cost savings and stability of solar energy make it a more financially viable option in the long run.

These findings align with existing literature and theoretical frameworks on the economics of renewable energy. Several studies have highlighted the declining costs of solar photovoltaic (PV) technology and the increasing cost-competitiveness of solar energy compared to traditional energy sources (Bhandari et al., 2022; Feldman et al., 2021). As the initial investment costs of solar PV continue to decrease and the operating costs remain low, the financial advantages of solar energy become more apparent.

The concept of levelized cost of electricity (LCOE) is widely used to compare the cost-effectiveness of different energy sources, taking into account the total lifecycle costs (Ouyang & Lin, 2020). The secondary data findings from Zimbabwe align with global trends, indicating that the LCOE of solar PV is becoming increasingly competitive with grid electricity and fossil fuels.

Furthermore, the financial advantages of solar energy extend beyond household and business cost savings. The literature also highlights the potential for job creation and economic development in the renewable energy sector Aydin, (2019), which resonates with the findings in Murewa district.

Overall, the findings contribute to the growing body of evidence supporting the financial viability and economic advantages of solar energy, particularly in rural and developing contexts. As the costs of solar technology continue to decline and the environmental and social costs of traditional energy sources are increasingly recognized, the financial case for transitioning to solar energy becomes stronger.

However, it is important to note that the upfront costs of solar power systems remain a significant barrier for many households and communities, especially in low-income regions. Efforts to address this challenge through innovative financing mechanisms, government incentives, and international support will be crucial to accelerating the adoption of solar energy and unlocking its financial and economic benefits.

4.5 Perceptions and Plans for Solar Power Project Sustainability

The research revealed mixed perceptions and plans regarding the sustainability and future maintenance of the solar power projects in Murewa district. While 62% of respondents expressed optimism about the long-term sustainability of the projects, 38% expressed concerns about the challenges associated with maintaining the systems over time.

Regarding maintenance plans, 48% of respondents indicated that they had received training on basic maintenance tasks, such as cleaning the panels and checking connections. However, only 28% felt confident in their ability to perform more complex repairs or replacements.

One respondent, a 39-year-old male, stated, *"I was trained on how to clean the panels and check for any visible issues, but if there's a more serious problem, I don't have the skills or tools to fix it myself."*

Furthermore, 57% of respondents believed that external support from technicians or experts would be necessary for ensuring the long-term maintenance and sustainability of the solar power systems.

A 46-year-old female respondent commented, *"We need ongoing support and guidance from professionals to ensure that our solar systems continue to function properly over the years. We can't rely solely on our limited training."*

4.6 Chapter summary

Chapter 4 explored the presentation and interpretation of the data gathered using several techniques, such as questionnaires, and observations. The chapter commenced by presenting a summary of the demographic attributes of the participants, including age, gender, and educational attainment, which aided in establishing the background of the sample population.

The chapter subsequently examined the adoption and utilisation trends of solar power technology across homes and communities in Murewa District. The presentation provided information regarding the quantity of houses that are utilising solar electricity, the factors influencing their decision to adopt this technology, and the various types of solar systems being used. This section included valuable information regarding the level of solar power integration in the region and the factors that influence its adoption.

In addition, the chapter analysed the economic consequences of implementing solar electricity. The study examined the income-generating activities facilitated by solar power, the introduction of novel business prospects, and the alterations in household incomes and expenditure patterns. This section elucidates the capacity of solar power to stimulate economic growth and advancement in rural areas.

The study also examined the societal effects of solar power, such as improved access to lights for educational purposes, the creation of community centres powered by solar energy, and the resulting affects on healthcare. This element emphasised the capacity of solar electricity to enhance the overall standard of living and social welfare of rural people.

The chapter specifically addressed the environmental consequences by emphasising the contribution of solar power in diminishing dependence on fossil fuels and promoting consciousness regarding sustainable energy practices. This part emphasised the significance of utilising renewable energy sources to address environmental concerns.

In addition, the chapter discussed the difficulties encountered while implementing and using solar electricity, including the significant initial expenses, maintenance concerns, and the requirement for external assistance and training. The difficulties were subjected to critical analysis in order to discover viable solutions and areas that may be improved.

The chapter also explored the community members' thoughts and attitudes towards the effectiveness, cost, sustainability, and other associated aspects of solar electricity, using survey and interview data. This section offered significant perspectives on the societal reception and comprehension of solar power technology within the community.

CHAPTER 5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary of Major findings

The effective implementation of solar power projects is influenced by several factors. A significant barrier is the lack of awareness and knowledge about solar technology among potential users, which can lead to resistance and slow adoption rates. High upfront costs of installation are another major obstacle, making it difficult for many communities, particularly in rural areas, to afford the initial investment required for solar power systems. Additionally, there is often limited technical expertise available for both the installation and maintenance of solar equipment, which can compromise the performance and longevity of these systems.

Inadequate policy and regulatory frameworks further hinder the widespread adoption of solar power. Without strong governmental support, including incentives and subsidies, the financial burden remains high for end-users. Infrastructure challenges such as poor road networks and limited access to essential equipment and spare parts also pose significant hurdles, as they can delay project timelines and increase costs.

Despite these challenges, solar power projects present numerous opportunities. Economically, they can stimulate income generation, create employment, and open up new business ventures. Socially, solar power can lead to improved education, better healthcare, and enhanced community centers by providing reliable energy. Environmentally, the adoption of solar energy reduces reliance on fossil fuels, lowers greenhouse gas emissions, and promotes sustainable practices. Politically, solar projects can empower communities, encourage local participation in energy policy decisions, and drive positive changes in local governance.

Financially, solar energy offers several advantages. Although the initial costs are high, the long-term operating and maintenance costs are significantly lower compared to traditional energy sources. Solar power provides more stable and predictable costs, which can be a considerable advantage over the volatile prices of fossil fuels and grid electricity. Over time, solar energy can lead to substantial cost savings, especially in rural areas where access to conventional energy sources is limited. Additionally, reliable energy access through solar power can facilitate income generation and create business opportunities.

Perceptions of project sustainability and maintenance are mixed. While 62% of respondents are optimistic about the sustainability of solar projects, 38% express concerns about maintenance

challenges. About 48% of the community members have received basic maintenance training, but only 28% feel confident handling complex repairs. A majority, 57%, believe that external support is necessary for the long-term maintenance of solar systems. Concerns also exist regarding the availability of spare parts and the potential obsolescence of solar technology. Levels of community involvement and ownership vary, affecting the sustainability and success of these projects.

5.2. Conclusion

Effective implementation of solar power projects in rural areas requires a comprehensive approach that addresses key issues such as awareness, affordability, technical capacity, supportive policies, and infrastructure development. Solar power projects have the potential to create substantial economic, social, environmental, and political benefits, contributing to sustainable development and empowering rural communities. While the initial costs may be higher, the long-term financial benefits, including cost savings, stability, and opportunities for income generation, make solar energy a viable option, particularly in areas with limited access to traditional energy sources. Ensuring the sustainability and maintenance of solar power projects necessitates ongoing technical support, capacity building, access to spare parts and upgrades, and fostering community ownership and participation. Collaboration among communities, local authorities, and stakeholders is essential for addressing the interconnected factors that impact the long-term viability and sustainability of solar power projects in rural areas.

5.3. Recommendations

To effectively implement solar power projects, communities and local authorities need to take proactive measures. They should initiate community awareness and education campaigns to inform people about the benefits of solar technology. Innovative financing mechanisms, such as lending schemes and pay-as-you-go models, should be explored to make solar installations more affordable. Establishing community training programs is essential to develop the local technical expertise required for the installation and maintenance of solar systems.

Government and policymakers also play a crucial role in the successful implementation of solar projects. They need to develop a comprehensive policy and regulatory framework that includes incentives to encourage the adoption of solar power in rural areas. Providing subsidies, tax incentives, or financial assistance can significantly increase the affordability of solar

installations. Additionally, investing in infrastructure, such as improving roads and distribution networks, is vital to ensure easy access to solar equipment and spare parts.

Solar power projects create numerous opportunities for communities. Local authorities should focus on fostering community ownership and participation in the decision-making and implementation processes of these projects. Developing sustainable financing mechanisms, like maintenance funds, can ensure the long-term viability of solar power systems.

The private sector and NGOs can contribute by engaging in public-private partnerships and collaborative initiatives that support solar projects. They should also back awareness campaigns and educational programs to promote the benefits of solar energy and encourage its adoption.

For the sustainability of solar power projects, communities and local authorities should develop sustainable financing solutions, such as community maintenance funds or savings schemes. This will help ensure ongoing support and maintenance of solar systems. Government and policymakers should establish a regulatory framework to ensure quality assurance and monitoring of solar installations.

The private sector and NGOs can assist by providing technical assistance, training, and capacity-building programs. Developing business models that ensure the availability of equipment and spare parts in rural areas is also crucial for the long-term success and sustainability of solar power projects.

5.4. For Future Research

Future research should focus on longitudinal studies to assess the long-term impacts and sustainability of solar power projects. Investigating socio-cultural factors that influence the adoption of solar energy is important to understand and address potential barriers. Exploring the integration of solar power with other renewable energy sources and storage solutions can enhance the efficiency and reliability of energy systems. Additionally, examining the economic and environmental implications of scaling up solar projects is necessary to understand their broader impact. Research should also delve into community management models for the long-term maintenance of solar systems, ensuring that these projects remain viable and beneficial in the long run.

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APPENDIX

SAMED

P Bag 1020
BINDURA
ZIMBABWE

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Fax: 263 - 71 - 7616

BINDURA UNIVERSITY OF SCIENCE EDUCATION

Date: .....

TO WHOM IT MAY CONCERN

NAME: ..... REGISTRATION NUMBER: .....

PROGRAMME: ..... PART: .....

This memo serves to confirm that the above is a bona fide student at Bindura University of Science Education in the Faculty of Science Education.

The student has to undertake research and thereafter present a Research Project in partial fulfillment of the programme. The research topic is:

In this regard, the department kindly requests your permission to allow the student to carry out his/her research in your institutions.

Your co-operation and assistance is greatly appreciated.

Thank you

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Z. Ndemo (Dr.)
CHAIRPERSON - SAMED

APPENDIX 2

QUESTIONNAIRE FOR HOUSEHOLDS WITH SOLAR SYSTEMS

1. What is your household's monthly income?
   Below $100 ☐ $100-$200 ☐ $200-300 ☐ above $300 ☐
2. What is your highest level of education?
   Diploma ☐ Degree ☐ Masters ☐ PHD ☐
   Certificate ☐
3. What type of solar power system do you use?
   less 1 KV ☐ 1KV to 2KV ☐ Above 2KV ☐
4. How did you aquire your solar power systems?
   NGO ☐
   Community initiative ☐
   Personal investment ☐

5. How has solar power affected your household's food security?

Ability to grow crops ☐

Ability to store food ☐

Ability to buy food ☐

6. Do you feel that solar power has improved your overall quality of life?

YES ☐ NO ☐

7. Do y think solar power has affected your community's economy?

YES ☐

NO ☐

8. Has solar power improved your access to safe drinking water?

YES ☐

NO ☐

9. Do you have any challenges or concerns related to the use of solar power in your household?

YES ☐

NO ☐

10. What do you use solar power for?

Lighting ☐

Cooking ☐

Entertainment ☐