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Assessing Factors Influencing Solar Energy Adoption among Small and Medium Enterprises in Mzuzu City, Malawi

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Abstract

One of the many renewable energy sources that offer advantages is solar energy, which also lowers energy prices and promotes environmental sustainability and energy security. Despite these advantages, various barriers, such as installation costs, have prevented small and medium-sized enterprises from investigating this invention. Malawi has a significant energy shortfall such that most businesses have been hindered from their profit maximization goals. The "Photovoltaic systems" (PV) that transform sunlight into electricity are the subject of this study. This type of solar energy system is situated on the building's roof and generally produces electricity for businesses and even homes. Solar energy offers a great impact to small and medium enterprises in Mzuzu city with a cost-effective and dependable alternative to energy that has the potential to change the game. Therefore the aim of the study was to identify factors that encourage the adoption of solar energy among small medium enterprises in the city of Mzuzu city. And to identify some of barriers faced when adopting solar energy among small and medium enterprises in the city of Mzuzu. The research approach employed in the study was a survey. A survey is a type of research methodology in which primary data is gathered from a sample using a questionnaire. When information is to be gathered from a wider sample, a survey is employed. A bigger sample size was needed in this study in order to facilitate hypothesis testing. It is advised to apply a logical approach while using the survey. The survey utilized a five-point Likert scale. The study used convenience sampling to select study participants. The sample size in this study was determined using Cochran's sample size formula. Statistical Package for Social Sciences (SPSS) and Microsoft Excel were used for statistical analysis. About 97.2% of the participants were aware of solar as a source of energy compared to 2.8 % who were unaware. The majority of participants use solar energy for lighting only, seconded by those

who use electricity. The least number of participants use solar energy for cooling only. The majority of participants 21.5% indicated partnership and collaboration as the most motivating factor for the adoption of solar energy. This was followed by technical expertise 19.1 % the least number of participants 10.8% expressed that policy and regulatory frameworks were associated with the adoption of solar energy. This study found that there are no statistically significant factors influencing barriers to the adoption of solar energy. The price of solar energy adoption was identified as the least factor associated with the acceptance or rejection of solar energy. Nonetheless, the reasons given by the homes that had embraced solar technology aligned with the findings of other studies. This survey also found that although the public was aware of solar energy, and technology, there were still a number of factors that mattered, especially for non-adopters.

Keywords

Solar Energy, Small and Medium Enterprises, Solar Energy Adoption

1. Introduction

The use of solar energy development has drawn attention in recent years due to its potential to mitigate the challenges posed by changes in the environment and energy demand. One renewable energy source that offers several advantages is solar energy. These advantages include lower energy prices, increased energy security, and environmental sustainability. Notwithstanding these advantages, a few obstacles, such as installation costs, have prevented small and medium-sized businesses from investigating this invention. Malawi, like several other developing countries like Mozambique, Angola, and Burundi, has a substantial energy deficit. The nation's restricted ability to generate electricity has prevented the majority of firms from achieving their objectives of maximizing profits [1].

Governments worldwide have pledged to take concrete steps to lessen the environmental impact of human activities and have set air pollution emission targets in reaction to climate change. Increasing the utilization of renewable energy sources including solar, wind, nuclear, geothermal, and hydropower to generate electricity is one of the steps taken to accomplish this objective. It is often believed that large investment projects launched by government agencies or well-known power-generating companies are responsible for the widespread adoption of specific renewable energy sources like wind and hydropower. The cost of solar photovoltaic (PV) systems, on the other hand, has been steadily declining over the last fifteen years. Distributed solar generation is now more accessible to more people because of legal developments that have made it easier to connect it to the electrical grid. Thus, solar energy holds great promise as a dependable alternative for residential, agricultural, and commercial enterprises. This study specifically examines "photovoltaic systems" (PV), which harness sunlight to generate elec-

tricity. Typically situated on the rooftop, this type of solar energy system produces electricity for both homes and commercial establishments. Solar energy offers a multitude of advantages. For example, it offers a dependable source of energy using clean technology that produces no emissions during operation and can be easily installed in urban areas without the need for additional land. This is advantageous for small and medium-sized businesses that primarily lease space [2]. Malawi is experiencing a significant expansion in the solar technology industry. Despite being a relatively new field, only a handful of businesses have been able to recognize and capitalize on this opportunity for their company.

In addition to Africa, the installation of solar panels is gaining popularity in foreign countries as a unique solution to meet global energy demands. Small and medium enterprises require a reliable and consistent energy supply. Nevertheless, no matter how advanced the country's progress may be, only a fraction of the immense solar energy capacity has been harnessed. Given the significant impact on both business and the environment, it is essential to thoroughly examine the factors that affect the adoption of solar energy [3]. This study examined the factors influencing the adoption of solar energy among small and medium-sized enterprises in Mzuzu City, Malawi. Past studies on the uptake of solar energy in African countries have mainly focused on analyzing national- level factors. This had the disadvantage that the requirements for different cities often vary from each other due to factors such as industrialization. Instead of making broad generalizations at the national level, which can lead to a significant amount of confusion when trying to understand the factors influencing the acceptance of solar energy, this study has focused on providing specific statistics for a single city. This research has revealed previously unrecognized factors that contribute to the hidden adoption of solar energy, especially in impoverished countries such as Malawi.

It worldly known that energy is a key ingredient in the economic development of any economy with a significant impact on a country's commercial and industrial activity [4] [5]. This study looked at factors influencing solar energy adoption among small and medium enterprises in Mzuzu City, Malawi. Energy access is essential for economic development which helps to reduce poverty by promoting and enabling investments in new industrial and commercial ventures and innovations that encourage job creation and the improvement of the overall quality of life in nations "Energy Home" [6]. One of the United Nations' Sustainable Development Goals (SDG) is to ensure that all people have access to modern, cheap, dependable, and environmentally friendly energy. This goal is stated explicitly in the Sustainable Development Goals: Sustainable Development Knowledge Platform [7]. All countries are expected to adopt the objectives of this goal with the aim of mitigating climate change, ending world poverty and promoting shared world prosperity "Energy Home. Energy access is affected by many factors including the affordability and willingness to adopt the available energy solutions by human populations or communities and it is therefore no

wonder that an estimated 840 million people worldwide have no access to electricity with millions more having to live with unreliable or limited access. Close to three Billion people use polluting fuels like wood and biomass to cook and heat their homes with the obvious consequences of air pollution and negative health impacts. Energy consumption and supply are out of balance globally, with demand currently exceeding supply. This imbalance is expected to persist into the future, which will have an impact on adoption and accessibility. The "World Energy Outlook 2018—Analysis" by the International Energy Agency (IEA) predicts that global energy consumption will increase by about 25% of the present demand by 2040. This growth will primarily come from developing nations, with India being the largest contributor. More than 80% of this demand growth is anticipated to come from low carbon (clean energy) technologies, with electricity expanding at a rate faster than the total amount of energy consumed from all other sources combined. Despite the growing demand for power, global carbon emissions are projected to keep rising, and the objective of achieving universal access to energy worldwide will remain unattainable in the near future [8].

On the energy supply side, the Global Trends in Renewable Energy Investment Report, by the United Nations Environment Program (UNEP) indicated that solar power energy technology attracted more investment than any other energy technology. Solar power alone took up 57% share of the investments in all renewable energy (except hydro-power). China led the way with more than 53% of total global investments in solar energy, with Australia and Sweden also making significant investments during the same period. The very rapid increase in solar energy production is a clear indicator that the world energy map is changing and shifting towards increased use and production of renewable energy. In 2017 alone, 157 gigawatts of renewable energy were added to the global energy sector and therefore boosting energy availability deficit and gradually moving towards universal access. Of these, solar energy alone added more energy than coal, gas and nuclear energy combined and solar (PV) energy is now considered the world's fastest growing energy technology. Demand for solar (PV) is on the rise worldwide and is now rated the most competitive option to generate electricity in some global markets. The increased demand is mainly driven by high demand in Europe and the emerging markets. As solar energy production has increased, so have consumer prices dropped on account of economies of scale and thus favouring access, adoption and eventual use [9].

Solar energy is one of the renewable energy options available for use in the less developed countries in sub-Saharan Africa. Solar energy is harnessed using two main primary technologies: Solar photovoltaics (PV), which are commonly called cells and operate in an electronic manner to convert light directly to electricity. Solar PV technologies can be batched into several interconnected units to provide electricity on a domestic, commercial or industrial scale. Concentrated Solar Power(CSP), uses heat from the sun (thermal energy) by directing the rays to mirrors that concentrate them to generate heat that is used to heat fluid to

create steam to drive utility-scale, electric turbines that generate electricity.

Despite the abundance of energy sources, rural sub-Saharan Africa, the subcontinent has the highest energy deficit in electricity supply. It has for a long time relied on kerosene and firewood as the primary and main sources of energy with their attendant environmental problems and associated health risks including the negative impact on economic development. Clean and reliable energy access has therefore remained a mirage for a large majority of rural households. Efforts such as those of Clean Energy Minigrids supported by the Alliance for Rural Electrification representing a broad group of donors and stakeholders in the minigrid value chain [10] are only but important steps towards sustainable and clean energy access. Solar minigrids are now extensively used to provide stand-alone and remote electricity supply in areas not served by national grids and are proving to be an excellent method of providing electricity and improving energy access to remote locations. Because the demand for the utilization of solar technology has improved in the last few years, the cost of production has come down due to increased economies of scale, thus gradually becoming the cheapest and most affordable form of energy, a plus for access and adoption. Solar panels have a general lifespan of 30 years [11].

In spite of the efforts by UNDP, the opportunities for increasing solar energy production in Africa remain largely untapped and therefore appropriate policies will need to be deployed by the various governments on the continent to expand solar energy production while promoting technology transfer and diffusion. Solar energy has the potential to be a key factor in driving the economic growth and diversification of investment options and opportunities in Africa if appropriate measures are taken to exploit existing solar energy generation potentials on the continent. For the investments to occur, there has to be an enabling environment for private sector players to invest in solar energy and the solar energy sector will require relevant support in setting product quality standards, training industry service support technicians and active efforts to ensure technology transfer including promotion of widespread adoption of solar energy technology (United Nations Development Program The Energy Access Situation in Developing Countries A Review Focusing on the Least Developed Countries and Sub-Saharan Africa [12].

Small and medium enterprises in most cities in Malawi are especially impacted by this energy emergency as they depend on expensive and untrustworthy framework power. Solar energy offers a great impact to small and medium enterprises in Mzuzu city with a cost-effective and dependable alternative to energy that has the potential to change the game. Mzuzu City is one of the major commercial centers in Malawi, with a significant number of small and medium enterprises. Presently, the significance of an uninterrupted power supply has become more prevalent due to rapid population growth, urbanization, and industrialization. Small and medium Enterprises such as manufacturing, agriculture, industry, and commerce require a clean and stable energy supply for business activity; in

fact, small and medium Enterprises are the indispensable engines which drive economic growth. Hence, adopting solar energy has been widely acknowledged as a business opportunity which boosts productivity in the economic sector. With evidence from the World Bank, around 85% of Malawi's population is not connected to the national grid, and some areas that are connected are plagued by recurrent power outages. Electricity demand has been growing consistently at 6% - 8% per annum. Over 95% of Malawi's electricity is generated from hydropower with Shire River as the main source of the hydroelectricity. Persistent electricity challenges have provided a strong case for Malawi's need to develop a robust market for solar energy technologies. The country needs to generate around 1,200 megawatts to meet the demand for electricity. Nevertheless, the country produces only about 441.95 megawatts of electricity presently, which results in a power shortage and makes it difficult and practically impossible for small businesses to perform efficiently in commercial cities. Thus, the government of Malawi encouraged the use of renewable energy such as solar electricity among small and medium enterprises as an alternative means for increased Productivity In conclusion, small and medium enterprises in Mzuzu city Mzuzu have been especially impacted by this energy emergency as they depend on expensive and untrustworthy framework power. As it has been said earlier, solar energy offers a great impact on small and medium enterprises and it also has the potential to become a reliable alternative for homes, farms, commercial and service businesses. Mzuzu City is one of the major commercial centers in Malawi, with a significant number of small and medium enterprises operating, therefore this brings attention to the objective of this study, which is to analyze the factors of the adoption of solar energy and bringing about its benefits to the business world. Ma urging the lawi has a particularly low rate of power availability compared to other countries in sub-Saharan Africa [13]. While the majority of Malawi's population resides in rural regions with a meager energy availability rate of 7%, only fifteen percent of the population as a whole has the ability to utilize it, according to the World Bank in 2023. The Malawian government has committed to achieving SDG 7, which aims to provide universal access to energy by 2030. The government recognizes that increasing access to electricity is crucial for the long-term stability of the nation; Government of Malawi [14]. However, the low financial performance of Malawi's national grid operator, Electric Supply Corporation of Malawi (ESCOM), is believed to be a significant barrier to increasing access to electricity. The infrastructure [15]; The World Bank, reported that the frequent load shedding makes it difficult for the utility operator to maintain the current grid connections, let alone extend them. The primary focus of the Malawian government's national electrification plan is on off-grid technologies. The 2017 Malawi Renewable Energy Strategy, as outlined by the Government of Malawi, sets a target of achieving a 45% adoption rate of renewable energy among the population by 2030. This would encompass around 11.2 million individuals, as estimated by the United Nations in 2022. These gadgets will be distributed through the private off-grid

solar (OGS) market and will enable businesses and families to obtain electricity [16].

The goal of this study was to identify factors that influence solar energy adoption among small and medium enterprises in the city of Mzuzu city. To identify some of barriers faced when adopting solar energy among small and medium enterprises in the city of Mzuzu and to investigate the perceived advantages and drawbacks of implementing solar energy among these small and medium enterprises in Mzuzu, Malawi.

2. Methods

The study employed a deductive methodology. According to Saunders [17], a deductive method is grounded in positivist philosophy and utilizes hypothesis testing as its foundation. According to Zikmund, a deductive method employs deductive reasoning, a theory-building strategy that follows a logical path to reach conclusions. The study has created hypotheses to investigate the notion or belief that SMEs' intentions affect their adoption of solar energy. This indicates that an inductive strategy, which tries to produce a theory, was not used in the study. The inductive approach is defined by Saunders as a process that develops theory from observation. The inductive method draws conclusions from observation [18]. For statistical analysis, Microsoft Excel and the Statistical Package for Social Sciences (SPSS) were utilized. It is advised to save study data files in Microsoft Excel and SPSS [19]. For multivariate analysis, SPSS is advised [20]. Since there were several independent variables in this study, multivariate analytic software was required to analyze the effects of these variables. Even though Microsoft Excel has multivariate analysis capabilities, the researcher still favors SPSS over Microsoft Excel. Tables, charts, and descriptive analysis were performed using Microsoft Excel.

3. Results

The chapter presents the findings of the study and discussions. The chapter will start with findings and discussions on sample profiles then descriptive statistics. After descriptive statistics, findings on model diagnostic tests of least square regression will be presented and discussed. Finally, the STUDY will present regression outputs about research objectives.

The study had a sample size of 384 and 288 respondents participated voluntarily which represented a 75% response rate. In this section sample profiles such as age, gender, and education are discussed.

3.1. Age of Respondents

The study analyzed the age of respondents to determine how the results were impacted by age. Findings are presented in **Figure 1**.

From **Figure 1**, the study found that 81% of participants were aged 18 up to 29.

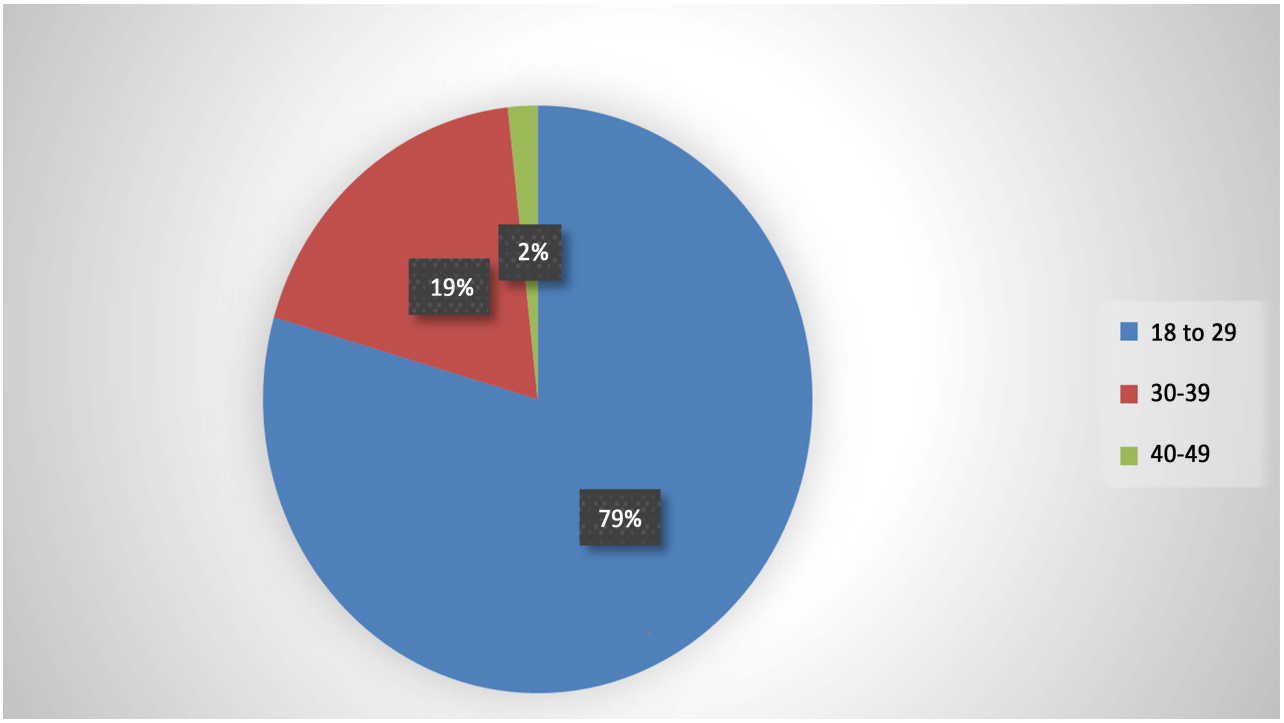

Figure 1. Distribution of participants according to age.

Further, findings established that 19% were participants aged between 30 and 39.

The adoption of solar energy by SMEs is influenced by age. For instance, Hwang showed that attitudes towards the adoption of solar energy are strongly influenced by age, with people between the ages of 18 and 25 responding more favorably to mobile payments than people 36 and beyond. According to [21], because they are more likely to be economically engaged, people between 18 and 60 years are more likely to utilize solar energy in small and medium-sized businesses. This demonstrates how certain age groups are restricted to certain economic pursuits, which may prevent them from actively embracing solar energy. The study's participants belonged to the age category of economically engaged individuals.

3.2. Gender of Respondents

Figure 2 shows that most study participants were males 83% and females 17%. This indicates that men made up the majority of study participants. Aini has shown that perceptions of solar energy adoption are significantly influenced by gender, with men generally viewing energy-saving initiatives more favorably than women [22]. But it was also shown by Ngonda, that women are less knowledgeable than men. Gender, thus, influences one's perceptions about solar energy adoption in Mzuzu, and male perceptions dominated this study.

3.3. Education Level

The study analyzed the education level of respondents to determine how the results were impacted. Findings are presented in Figure 3.

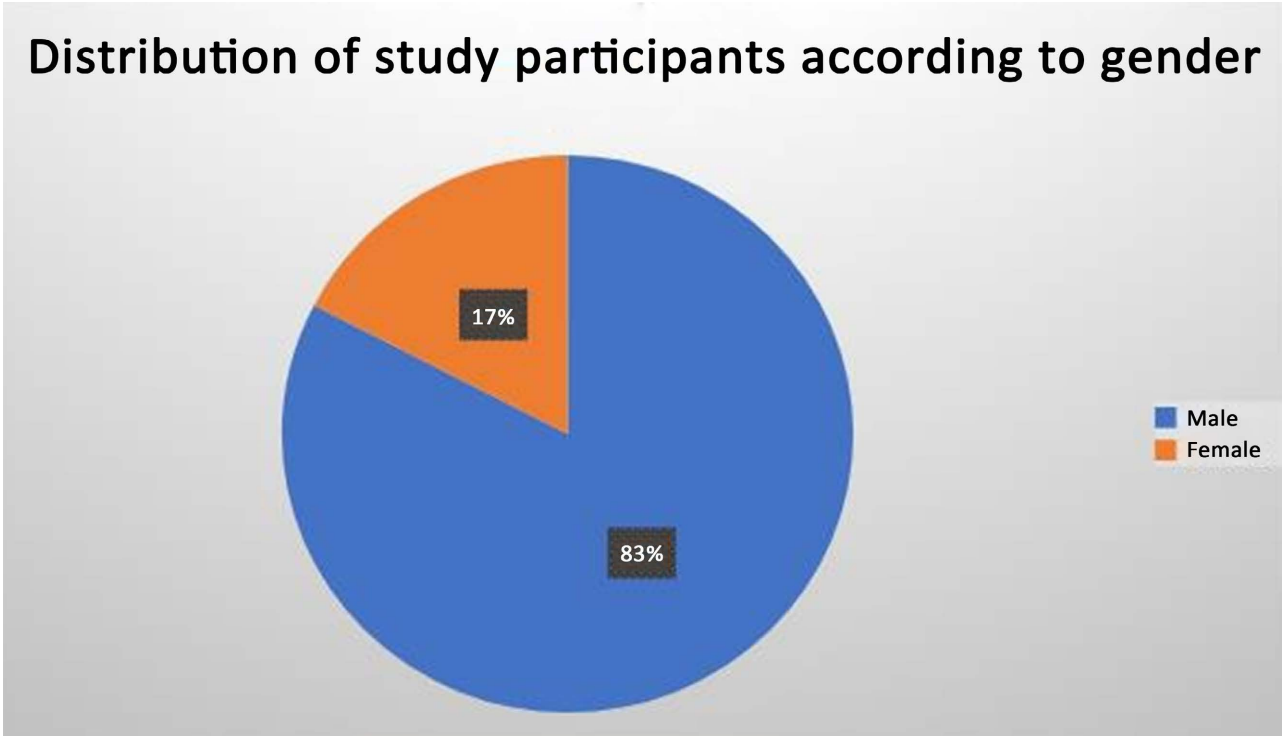

Figure 2. Distribution of study participants according to gender.

Based on the data presented in Figure 3, the research revealed that 12% of the participants had completed primary education, 30% had completed secondary education, 44% had attended college, 34% had completed an undergraduate degree, and 15% had completed a postgraduate degree. This indicates that individuals with college degrees as their greatest level of education dominated the survey. The government of Malawi heavily subsidizes education, which is given out for free up to the advanced level, and this could be one explanation for the situation. Furthermore, there hasn't been a cultural role that places limitations on who can receive an education, giving men and women equal access to it [23].

3.4. Marital Status

Based on Figure 4, most participants were single 185 followed by those who were married. The least number of participants were widows and widowers.

3.5. Source of Income

As shown in Figure 5, the main source of income for participants in our study was self-employment seconded by student activities. The lowest number of participants were those unemployed.

From Figure 5, the study found that at least 40% of the participants were employed with wages. While 90% of the participants were self-employed and 45% of the participants study. However, 10% of the participants were not employed. This means that the study was dominated by participants who were self-employed.

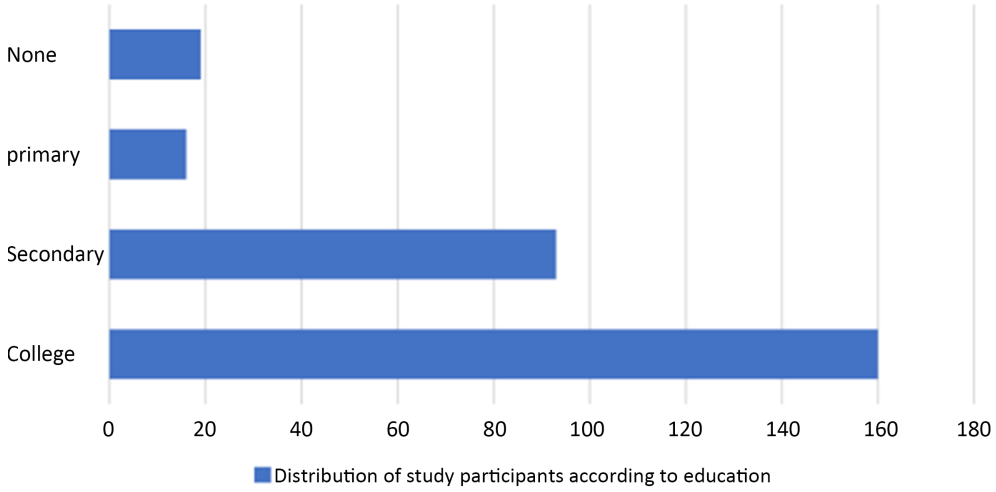

Figure 3. Distribution of study participants according to education.

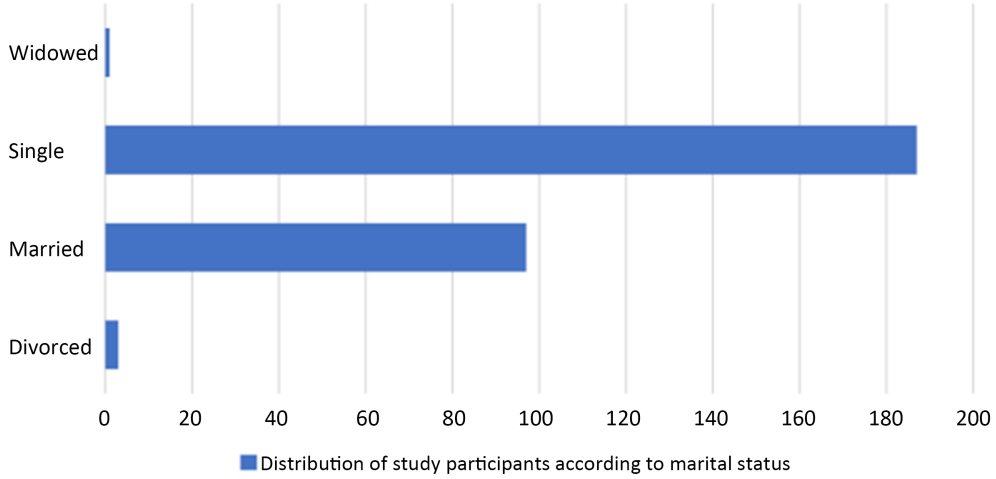

Figure 4. Distribution of study participants according to marital status.

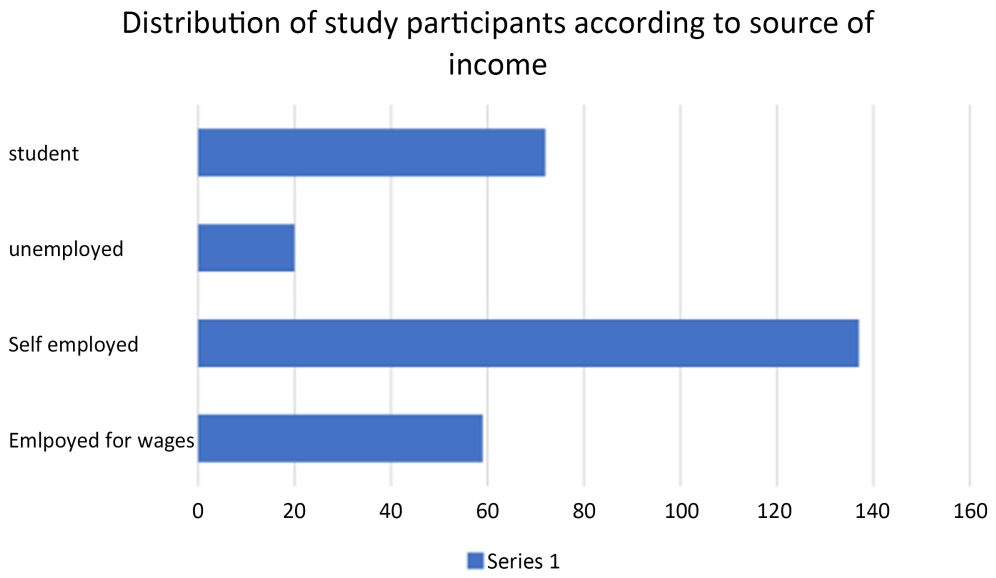

Figure 5. Distribution of study participants according to source of income.

Put another way, in small and medium enterprises, adoption power increases with the quality of its revenue source, potentially leading some of them to switch to solar energy technology. This is consistent with research conducted in Africa [24]. Consequently, measures that increase household income or improve purchasing power could be an effective tactic to encourage homeowners to embrace solar energy technology. This is because one of the key factors influencing the adoption of solar power in homes is household income.

3.6. Awareness of Solar Energy

As illustrated in Figure 6 below, about 97.2% (280) of the participants were aware of solar as a source of energy compared to 2.8% (8) who were unaware.

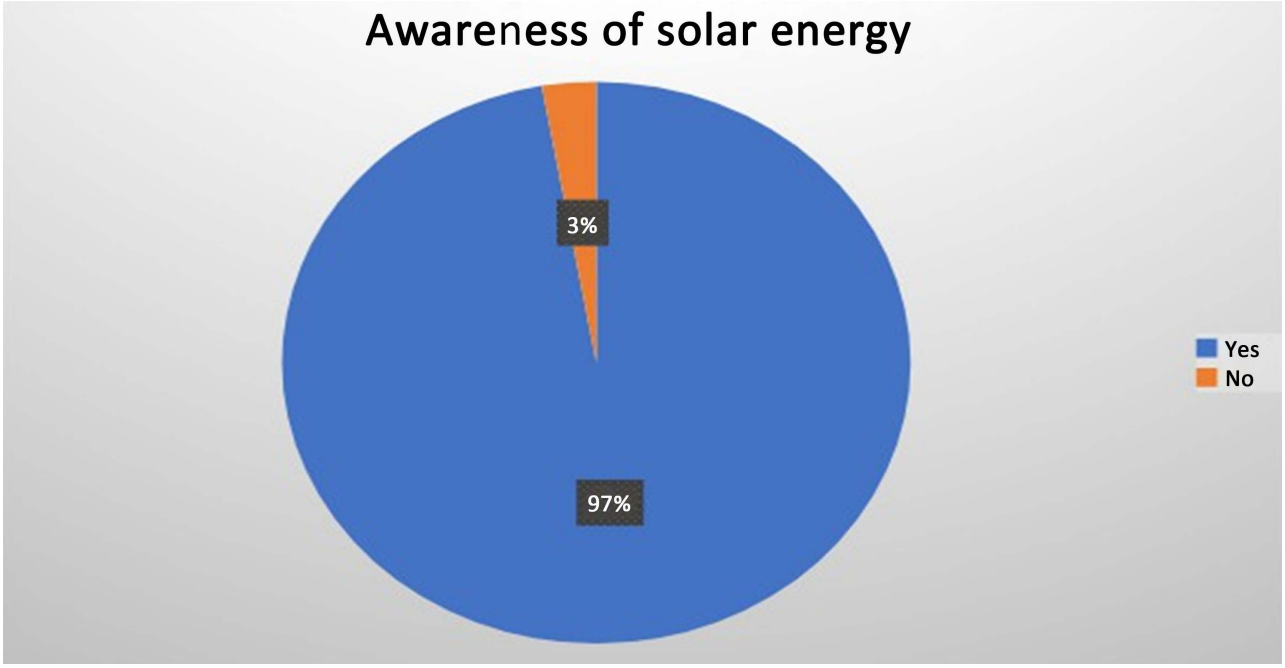

Figure 6. Distribution of study participants according to awareness of solar energy.

From Figure 6, the study found that 97% of the participants were aware of solar energy while only 3% did not know solar energy. This means that the study was dominated by participants who had enough knowledge about solar energy.

In line with our findings, [25] discovered that perceptions of the use of solar power rely on awareness and educational attainment. According to the survey, people who knew enough about solar energy thought that it would be adopted more favorably than people who didn't. The study also showed that people's attitudes towards using solar energy are positively correlated with their level of education.

3.7. Uses of Solar Energy

As illustrated in Figure 7 Majority of participants use solar energy for lighting only, seconded by those who use electricity. The least number of participants use

solar energy for cooling only.

3.7.1. Factors That Encourage the Adoption of Solar Energy

According to Figure 8 below, the majority of participants were on point 62 which represent 21.5%, indicated partnership and collaboration as the most motivating factor for the adoption of solar energy, the horizontal axis represents the number of small and medium enterprises. This was followed by technical expertise on point 55 representing 19.1% and the least number of participants expressed that policy and regulatory on point 31 which means 10.8% frameworks were associated with the adoption of solar energy.

The majority of participants in this study own companies with 1 to 9 employees 206 (71.5%), followed by those with 20 - 29 employees 54 (18.8%). The lowest number of participants belonged to those with greater than 50 employees in their establishments 7 (2.4%).

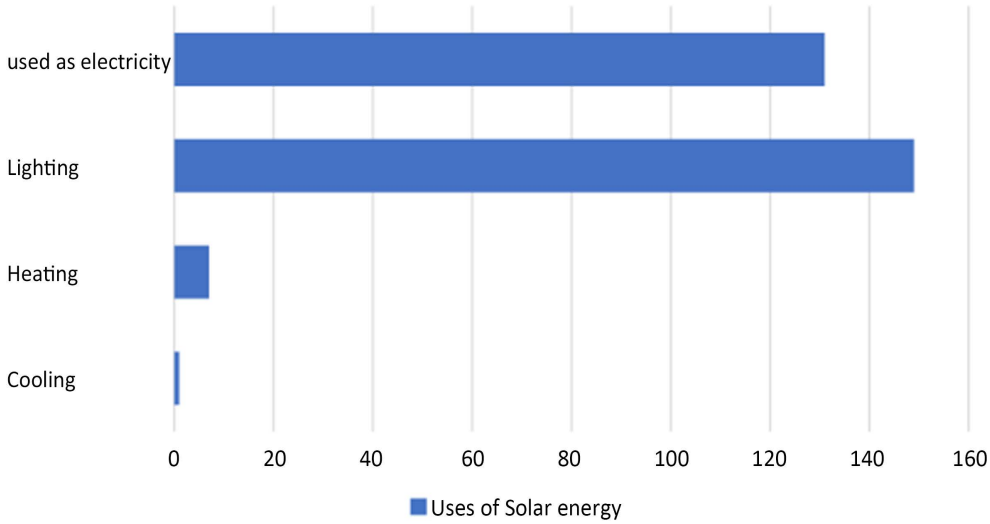

Figure 7. Distribution of study participants according to uses of solar energy.

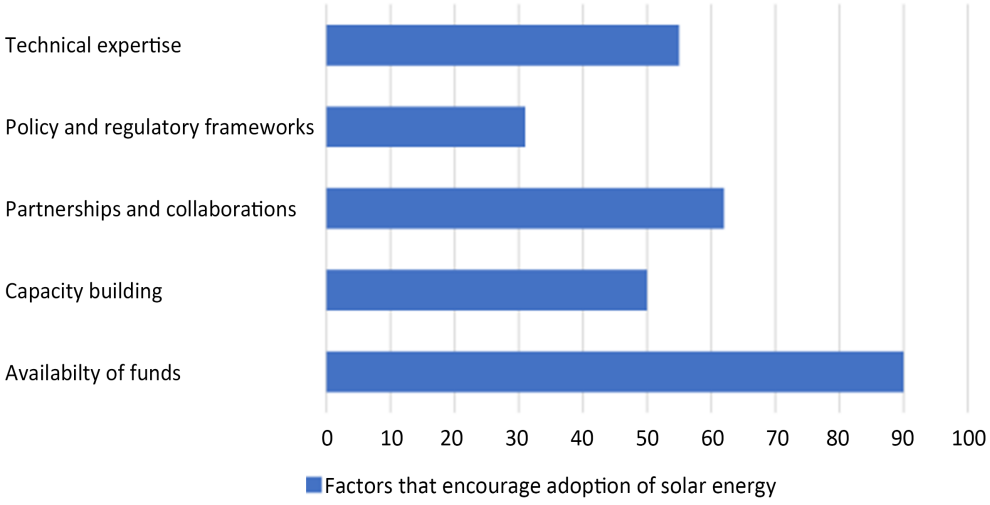

Figure 8. Distribution of study participants according to uses of solar energy.

3.7.2. Do You Face Barriers to Adopting Solar Energy

This study found that there are no statistically significant factors influencing barriers to the adoption of solar energy. None of the variables linked to adoption of solar energy had a statistically significant impact, according to the regression analysis results. In this situation the well-established nature of existing technologies presents a formidable barrier for renewable energy (Figure 9).

3.7.3. Association between Study Variables and Awareness of Solar Energy

As shown in Figure 10, the finding of this study indicates a statistically significant association between solar energy awareness and level of education. Such that there was an increase in solar energy awareness from primary (14), and secondary (92) with the highest indicated for those who attended college (157) ($P = 0.010$). All other variables did not indicate a statistically significant association with solar energy awareness ($P > 0.05$).

3.7.4. Factors Affecting Awareness of Solar Energy

The adoption of new technology is influenced by users' awareness of its benefits and weaknesses. Information gaps can hinder the acceptance of new technology. Adoption involves a series of processes in knowledge, conviction, decision, and confirmation. Consumers become aware of the innovation before adopting it. More knowledgeable consumers are more likely to adopt new products or services. The adoption process begins when consumers become aware of the new brand. Therefore, awareness is crucial for successful adoption of new technologies [26]. This study found that none of the demographic factors are associated

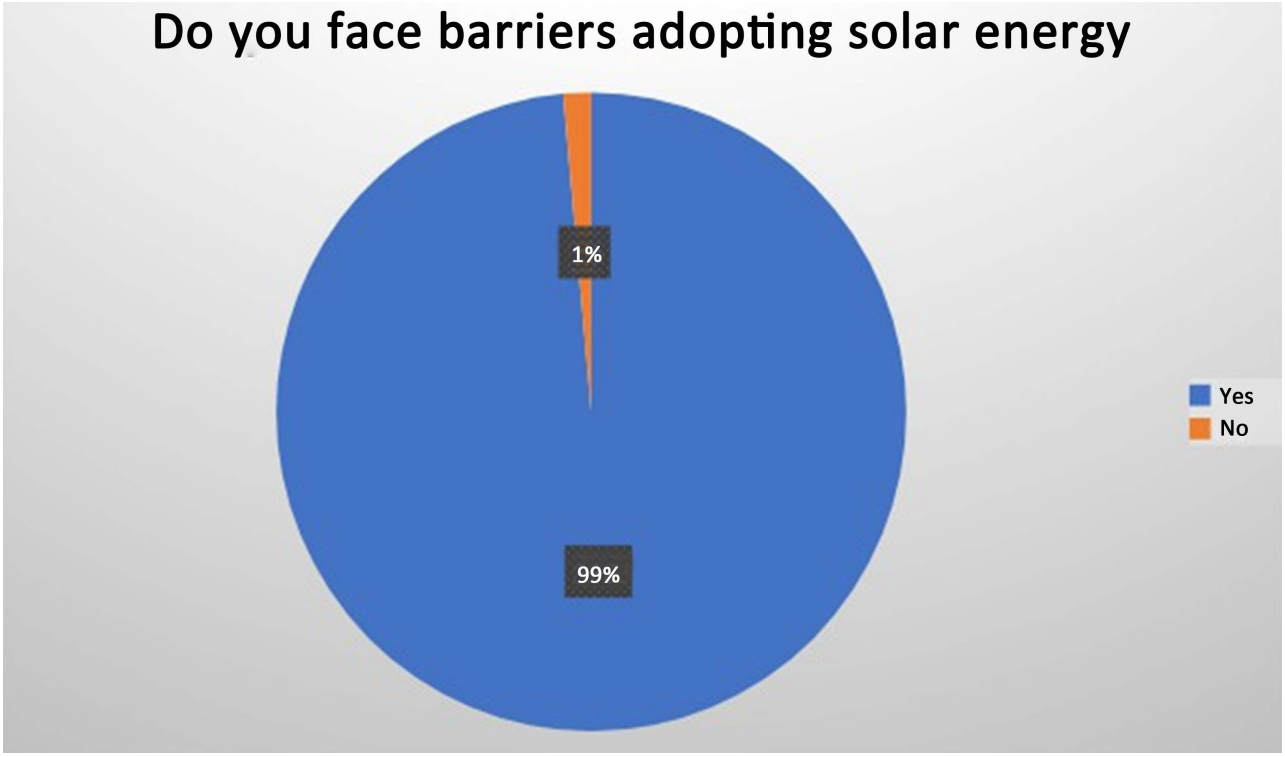

Figure 9. Distribution of barriers to adopting solar energy.

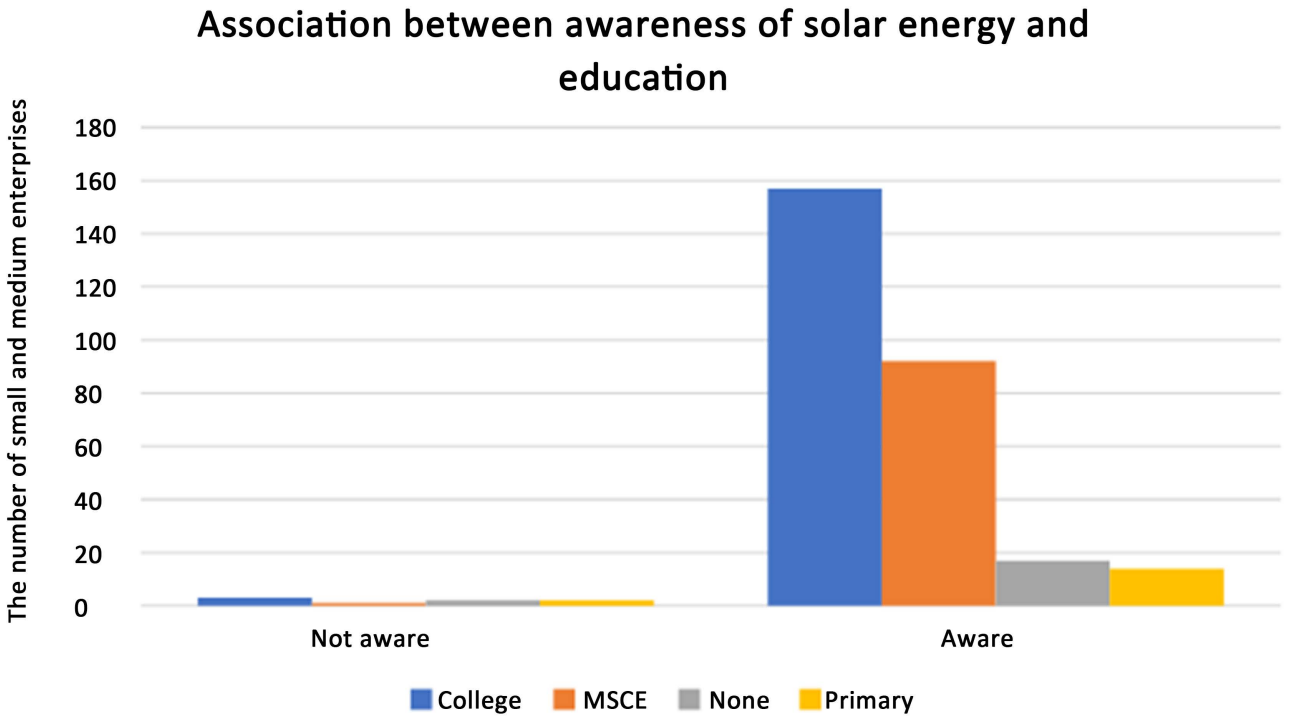

Figure 10. Association between solar energy and education.

Table 1. Model summary.

				Change Statistics				
Model	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.253a	0.020	0.16300	0.064	1.441	13	274	0.140

with Awareness of solar energy. In contrast, Karytsas, Analyzed information collected in a study done in Greece over the summer of 2012 to examine how demographic and socioeconomic factors impact an individual's awareness of different renewable energy sources. The study results indicate that gender, age, education level, head of household education level, environmentally friendly behavior, and having employment, studies, or hobbies related to environment, technology, or engineering are factors that are statistically significant in their connection with different sources of clean energy [27].

1) Model Summary

From **Table 1**, the R square is 0.064 which means that 6% of variation in awareness of solar energy is explained by only significant factors in the regression model. Further, the adjusted R square is .02 which means that 2% of variations in awareness of solar energy are explained by all factors in the regression model.

2) Analysis of variance (ANOVA)

The study tested if the R square and the regression model are a good fit for the study findings are presented in Table 2.

The table shows the F value of 1.441 which was nonsignificant (p = 1.40). This means that the probability that the variations in solar energy adoption in these enterprises are not influenced by explanatory variables which is the level of solar

energy awareness.

Table 2. ANOVA.

Model	Sum of Squares	Df	Mean Square	F	Sig.
1Regression	0.498	13	0.038	1.441	1.140b
Residual	7.280	274	0.027		
Total	7.778	287			

3.7.5. Factors Connected with the Barriers to Adoption of Solar Energy

This study found that there are no statistically significant factors influencing barriers to the adoption of solar energy. In contrast, Walters and colleagues in 2018 conducted a study to assess the adoption of solar energy in Chile. The authors asked a panel of Chilean PV specialists through Delphi research for their expertise to investigate this issue. These investigations produced 26 variables that affect the spread of PV in Santiago, including drivers and obstacles. Experts agreed on the relative significance of 21 out of the 26. According to the research, several factors have an impact on the proliferation of PV technology including social, technological, and economic aspects. Similar influences were noted by the specialists from the fields of finance, the environment, and energy supply (such as electrical dependability). They identified institutional, financial, technological, and knowledge-based impediments to adoption as emerging obstacles. Financial incentives (like subsidies) and financial obstacles (like large upfront expenses) were deemed to be the most significant elements impacting adoption, whereas environmental motives were deemed to be the least significant. In agreement, Vasseur and Kemp, Conducted an analysis of the determinants influencing the acceptance and rejection of solar photovoltaic (PV) technology in the Netherlands [28]. The primary objective of this article was to acquire knowledge and comprehend the implementation of photovoltaic (PV) technology in the Netherlands, focusing on the viewpoint of users. Our approach examines the impact of four factors: what is seen as the comparative benefit of the technology, the level of detail of the innovation, social influence, and the comprehension of grants and expenses. Various proxies are being utilized to examine individual components for each of the criteria. The impact of the four adoption determinants is examined across four distinct groups: voluntary adopters, involuntary adopters (individuals who purchased a property with pre-installed solar PV), potential adopters, and rejecters. For this study, we employed descriptive analysis and logistic regression analyses. The research demonstrated that the expense of a photovoltaic (PV) system is a crucial factor influencing the decision to embrace or not adopt PV technology in the Netherlands. Adopters perceive the costs of adoption as affordable, while non-adopters perceive them as too exorbitant. The disparities arise from the fact that adopters place a higher value on the advantages compared to non-adopters. This demonstrates that the act of adopting anything is contingent upon the way individuals perceive its attributes.

Furthermore, Mustafa conducted a study to identify the primary obstacles to the implementation of renewable energy projects in Pakistan via the use of an Analytical Hierarchical process (AHP) and a linear regression model (LRM). The report included 429 responses from individuals who work on solar projects. The investigation identified several important barriers to advancement, such as institutional support, financial circumstances, regulations, technological awareness, social and environmental awareness, market stability, and other unspecified elements. The most influential elements were identified by the AHP investigation as being effective policies, stable finances, technological know-how, institutional backing, stable markets, a variety of factors, and awareness of social and environmental issues.

The findings of our study are surprising considering that the majority of participants are aware of solar energy. Knowledge about solar energy technology among the public cannot be overemphasized. Research indicates that knowledge of the technology has a significant effect on solar energy technology adoption. More specifically, the adoption of solar energy technologies is positively impacted by awareness. As a result, people will instantly identify and link this technology with solar electricity. People will become more concerned about technology's ability to retain details, recognize patterns, and visualize them [26].

The Model summary is shown below in **Table 3**.

Table 3. Model summary.

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.215	0.046	0.001	0.42305	0.046	1.021	13	274	0.431

3.7.6. Factors Associated with Acceptance of Solar Technology among Small and Medium Enterprises in Mzuzu City

As illustrated in **Table 4** the majority of study participants indicated that the main factor for adopting solar energy in Mzuzu city is mainly due to cleanliness of the energy source. The finding of this paper is in unison with previous work. Hussein and Wahid postulated that in the global energy situation of the future, solar energy will be vital in pursuing sun-to-hydrogen as a way to produce sustainable energy. To prevent global warming, hydrogen is a renewable energy source that can replace fossil fuels and reduce carbon dioxide (CO2) emissions [29]. The findings of this study highlight the fact that smallholder farmers are aware of the relevance of using clean energy sources to prevent climate change effects and ensure sustainable development. Meeting the world's expanding energy needs in a sustainable and ecologically friendly way is one of the largest issues facing humanity, particularly in fast-developing nations with rising living standards and populations [30]. In this sense, the most important requirement is to offer sustainable energy alternatives.

The price of solar energy adoption was identified as the least factor associated with the acceptance or rejection of solar energy. In contrast According to a pre-

vious study conducted in southern Malawi, 52 % of the respondents mentioned that cheapness of the solar energy was a major advantage that attracted households to use solar [31]. The difference between the studies could be due to different study populations. For instance, the current study was conducted among smallholder enterprises whereas the previous study was conducted among households. Noteworthy, the use of solar study could be different among the groups due to different needs one being home use and the other for business.

The results of the regression analysis (Table 5) show that there is no statistically significant effect of any of the factors associated with the acceptance or adoption of solar energy. We attribute the findings of this study to a smaller sample size which could contribute to lesser statistical power.

Table 4. Descriptive statistics.

	Mean	Std Deviation	N
Clean energy	0.4549	0.49883	288
Energy independence	0.2118	0.40930	288
Hedge against higher energy prices	0.01215	0.32731	288
Reliable energy	0.2118	0.40930	288

Table 5. Model summary.

					Change Statistics				
model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.095	0.009	-0.001	0.42354	0.009	0.869	3	284	0.458

3.7.7. Relationship between Perceived Benefits of Solar Energy Adoption and Attitude towards Solar Energy

Pearson correlation (Table 6) showed that there is a statistically significant positive relationship between solar energy perceived benefits and attitudes towards solar energy adoption ($p = 0.031$, $r = 0.127$) in this case the more the Malawian government can provide financial incentives the more these small and medium will be interested in adopting solar technology.

Table 6. Correlations.

		Attitude	Perceived Advantage
Attitude	Person correlation	1	0.127
	Sig. (2-tailed)		0.031
	N	288	288
Perceive advantage	Person correlation sig. (2-tailed)	0.127* 0.031	1
	N	288	288

Correlation is significant at the 0.05 level (2-tailed).

This finding may seem counterintuitive at first, as one might expect a positive correlation between attitudes and adoption intention. There could be other factors influencing the relationship between attitudes and adoption intention that were not accounted for in this analysis.

Additionally, the correlation between attitudes and perceived advantage was also statistically significant at the 0.05 level. This suggests that individuals who have more positive attitudes towards solar energy adoption also perceive more advantages to adopting solar energy.

Overall, these results highlight the complexity of factors influencing solar energy adoption among small and medium enterprises and underscore the importance of considering multiple variables and potential confounding factors in future research on this topic.

3.7.8. Relationship between Attitudes towards Solar Energy and Solar Energy Adoption Intention

Pearson correlation showed that there is a week negative relationship between attitudes towards solar energy solar energy adoption intention and it was not statically significant. ($p = 0.452$, $r = -0.044$) (Table 7).

Table 7. Adoption intention.

		Adoption Intention	Attitude
Adoption intention	Pearson correlation	1	−0.044
	Sig. (2-tailed)		0.452
	N	288	288
Attitude	Pearson correlation	−0.044	1
	Sig. (2-tailed)	0.452	
	N	288	288

The weak negative correlation coefficient of −0.044 suggests that there is a slight tendency for individuals with more positive attitudes towards solar energy to have slightly lower intentions to adopt solar energy. However, the lack of statistical significance ($p = 0.452$) indicates that this relationship may have occurred by random chance and is not a reliable finding in the population.

It is important to note that correlation does not imply causation, and other factors not accounted for in this analysis could be influencing attitudes and adoption intentions towards solar energy. Further research with a larger sample size or additional variables may be needed to better understand the relationship between attitudes and adoption intentions in this context.

3.7.9. Relationship between Perceived Costs and Solar Energy Adoption Intention

Pearson correlation showed that there is a week positive relationship between perceived costs and solar energy adoption intention and it was not statistically significant. ($p = 0.358$, $r = -0.054$) (Table 8).

Table 8. Correlation coefficient.

		Adoption Intention	Perceived Cost
Adoption intention	Pearson correlation	1	0.054
	Sig.(2-tailed)		0.358
	N	288	288
Perceived installation cost	Pearson correlation	0.054	1
	Sig.(2-tailed)	0.358	
	N	288	288

Based on the Pearson correlation coefficient (r = −0.054) and the p-value (p = 0.358), we can conclude that there is a weak positive relationship between perceived costs and solar energy adoption intention. However, this relationship is not statistically significant at the 0.05 level. The Pearson correlation coefficient (r = −0.054) indicates a weak positive relationship between perceived costs and solar energy adoption intention. This suggests that as perceived costs increase, there is a slight tendency for solar energy adoption intention to also increase, although the relationship is very weak. However, the lack of statistical significance (p = 0.358) indicates that this weak positive relationship could have occurred by random chance. Hence, the data does not provide enough evidence to support the claim that there is a significant relationship between perceived costs and solar energy adoption intention in the population from which the sample was drawn.

3.7.10. Relationship between Perceived Costs and Attitudes towards Solar Energy

Pearson correlation showed that there is a week negative relationship between perceived costs and attitudes towards solar energy adoption and it was not statistically significant. (p = 0.573, r = −0.033) (Table 9).

Regarding the question about factors strongly associated with rejection to adopt solar energy, based on the correlation table you provided, the installation cost is strongly associated with rejection to adopt. The correlation coefficient between perceived cost and attitude is −0.033, suggesting a weak negative relationship, but since the p-value is 0.573, it is not statistically significant. The results of the

Table 9. Pearson correlation.

		Adoption Intention	Perceived Cost
@10.Whichofthefollowinga restronglyassociatedwithrejectiontoadopt = Installation cost	Pearson correlation	1	−0.033
	Sig.(2-tailed)		0.573
	N	288	288
Attitude	Pearson correlation	−0.033	1
	Sig.(2-tailed)	0.573	
	N	288	288

Pearson correlation analysis indicate that there is a weak negative relationship between perceived costs and attitudes towards solar energy adoption. The correlation coefficient of −0.033 suggests that as perceived costs increase, attitudes towards solar energy adoption tend to slightly decrease. However, this negative relationship is very weak, as the correlation coefficient is close to zero.

Keep in mind that the p-value aids in determining the statistical significance of the relationship between two variables, whilst the correlation coefficient reveals the direction and intensity of the relationship. Here, perceived costs alone may not have a strong enough impact on attitudes towards solar energy adoption to warrant statistical significance. Other factors may play a more significant role. This is in line with a recent study that investigated how perceived costs influence consumer attitudes towards wind energy adoption. By analyzing survey data and conducting regression analysis, the researchers explored the impact of perceived costs on consumer willingness to adopt wind energy technologies. Therefore, further research and analysis may be needed to identify other factors that could be strongly associated with rejection to adopt solar energy, as perceived costs alone do not appear to be a significant determinant of attitudes towards solar energy adoption based on the current analysis.

4. Conclusions

All of the small and medium-sized businesses (SMEs) in Mzuzu City, Malawi, were the study's population. A population consists of every member of a group. This implies that everyone who owns a SME belongs to a community of individuals who manage or own small to medium-sized businesses. Data on the number of individuals who own or operate SMEs in this city was not available. As a result, a sample approach for an unknown population was utilized in the study.

The study used convenience sampling. This sampling method involves selecting cases which can be easily accessed by the researcher. Creswell's definition of convenience sampling includes ease of access and willingness to participate [32]. This means that this type of sampling observes research ethics of voluntary participation. It is a technique used by researchers to collect data from a larger sample economically [19]. Saunders has criticized this method based on bias. This means that the technique does not give an equal chance for cases to be selected in a study. The second week of January 2024 saw the beginning of convenience sampling-based data collecting. This indicates that convenient data collection was possible for the investigation. A questionnaire was used as an online survey tool to gather data. Closed, or fixed-alternative, questions were employed in the survey. There were five sections in the questionnaire. Demographic data was presented in Section A. Information on the elements that promote small and medium-sized businesses to use solar energy was given in Section B. This indicates that continuous measurements were made of the dependent variable. Other independent factors, such as obstacles to and benefits of applying solar energy information, were explored in the other sections. Numerous researchers have

made use of questionnaires. As a result, the use of questionnaires in this study was justified and has scholarly backing.

For statistical analysis, Microsoft Excel and the Statistical Package for Social Sciences (SPSS) were utilized. It is advised to save study data files in Microsoft Excel and SPSS [19]. For multivariate analysis, SPSS is advised. Since there were several independent variables in this study, multivariate analytic software was required to analyze the effects of these variables. Even though Microsoft Excel has multivariate analysis capabilities, the researcher still favors SPSS over Microsoft Excel. Tables, charts, and descriptive analysis were performed using Microsoft Excel [20].

The data analysis method employed in the study was linear multiple regression analysis (LMRA). According to Saunders et al., LMRA is an analytical approach that may examine the connection between a dependent variable and several independent factors [17]. The adoption of solar energy by SMEs is the only dependent variable in this study, and the three independent variables are intention factors, perceived benefits, and obstacles encountered. This indicates that the study was well-suited for the application of multiple regressions. The following presumptions, however, must be met before this approach is used: linearity, normality, homogeneity of variance, autocorrelation, and collinearity [20]. The multiple regression equation, which was taken from Zikmund, is shown below. Age has an impact on SMEs' use of solar energy. People's opinions regarding the adoption of solar energy, for example, are highly impacted by age. Specifically, those between the ages of 18 and 25 respond more favorably to mobile payments than those 36 and older [33]. People between the ages of 18 and 60 are more likely to use solar energy in small and medium-sized enterprises because they are more likely to be economically involved, according to Bot, B. V., Sosso, [25]. This illustrates how some age groups are confined to particular economic endeavors, which can keep them from fully adopting solar energy. Participants in the study fell into the age group of people who were actively involved in the economy.

This suggests that the majority of the research participants were guys. Aini & Goh Mang Ling have demonstrated that gender has a substantial impact on attitudes toward solar energy adoption, with males typically viewing energy-saving programs more favorably than women. However, studies by Ngonda and Palm & Eriksson have also demonstrated that women lack men's level of expertise. As a result, gender affects how people perceive the adoption of solar energy in Mzuzu, and this study found that male perspectives predominated [34] [35].

The research showed that 12% of the participants had finished their elementary education, 30% had finished their secondary education, 44% had attended college, 34% had finished their undergraduate degree, and 15% had finished their postgraduate degree, based on the data shown in **Figure 3**. This suggests that the majority of respondents to the poll had college degrees as their highest level of education. One possible reason for the anomaly is that Malawi's government significantly subsidizes education, which is provided for free up to the

advanced level. Furthermore, there hasn't been a cultural role that denies men and women equal access to education by limiting who is eligible to pursue it [36] [37].

According to **Figure 6**, 97% of participants in the survey knew about solar energy, whereas only 3% did not. This indicates that individuals with a sufficient understanding of solar energy dominated the research.

Consistent with our results, Rai & Robinson found that awareness and educational achievement had an impact on how people perceive the usage of solar electricity. Those with sufficient knowledge of solar energy believed that it would be more widely embraced than those without such knowledge, according to the study. The survey also revealed a favorable correlation between people's views about solar energy use and their educational attainment [25]. As seen in **Figure 7**, the majority of participants exclusively utilize solar energy for illumination, with electricity users coming in second. The smallest percentage of participants only use solar energy for cooling.

4.1. Factors Impacting Solar Energy Awareness

Users' understanding of new technology's advantages and disadvantages affects its adoption. Lack of information can make new technologies more difficult to adopt. A number of processes related to knowledge, conviction, decision-making, and confirmation are involved in adoption. Before implementing the innovation, consumers become aware of it. Customers who are more informed are more inclined to use new goods or services. The moment customers learn about the new brand, the adoption process starts. For new technology to be successfully adopted, awareness is therefore essential [26]. According to this study, there is no correlation between any demographic aspect and solar energy awareness. On the other hand, Karytsas, S., & Theodoropoulou, H. Analyzed the socioeconomic and demographic factors influencing individuals' awareness of various renewable energy sources based on data collected from a survey conducted in Greece in the summer of 2012 [38]. Based on the study findings, several factors show a statistically significant correlation with various sources of renewable energy. These factors include gender, age, education level, head of household education level, environmentally responsible behavior, and having a job, studies, or hobby related to the environment, technology, or engineering.

4.2. Factors Impacting the Adoption of Solar Energy

The adoption of solar energy is not hindered by any statistically significant reasons, according to this study. On the other hand, Walters and associates carried out an evaluation of Chile's solar energy uptake in 2018. Through Delphi research, the authors enlisted the assistance of a panel of Chilean PV experts to look at this matter. These studies yielded 26 factors, including hurdles and drivers that influence PV's expansion in Santiago. Regarding the relative importance of 21 out of 26, experts were in agreement.

The study indicates that social, technological, and economic considerations all

have an effect on how widely PV technology is adopted. Experts in the domains of economics, the environment, and energy supply (including electrical reliability) saw comparable impacts. Emerging barriers to adoption were highlighted by them as being knowledge-based, institutional, financial, and technical. Environmental considerations were judged to have the least impact on adoption, whereas financial incentives (such as subsidies) and financial barriers (such as high upfront costs) were found to have the most influence.

In agreement, Vasseur and Kemp investigated the reasons for solar PV adoption and non-acceptance in the Netherlands. This paper's primary goal was to learn more about and comprehend PV adoption in the Netherlands from the standpoint of users. The perceived relative benefit of the technology, the innovation's complexity, societal impact, and grant and cost knowledge are the four components whose effects are examined in our research. Various proxies are being employed for each factor in an effort to analyze its constituent parts. Four types of persons are investigated in relation to the effect of the four adoption factors: potential adopters, rejecters, involuntary adopters (those who purchased a home with solar PV), and voluntary adopters. We employed both logistic regression analysis and descriptive analyses in this study. According to the report, one major factor influencing the adoption or non-adoption of PV in the Netherlands is the cost of a PV system. The costs of adoption are seen as reasonable by adopters while being excessively expensive by nonadopters. Adopters place a higher value on the advantages than do non-adopters, which explains the discrepancies. This demonstrates how attribute perceptions affect adoption [28].

4.3. Factors Associated with Acceptance of Solar Technology among Small and Medium Enterprises in Mzuzu City

The primary driver behind Mzuzu City's use of solar energy is the energy source's cleanliness. This paper's findings are consistent with earlier research. According to Hosseini and Wahid *et al.*, solar energy will be essential in the pursuit of sun-to-hydrogen as a means of producing sustainable energy in the global energy landscape of the future. Hydrogen is a sustainable energy source that can take the place of fossil fuels and lower carbon dioxide (CO2) emissions, hence preventing global warming [39]. The study's conclusions demonstrate that smallholder farmers understand how important it is to use renewable energy sources to mitigate the consequences of climate change and promote sustainable development. One of the biggest challenges confronting humanity is finding a sustainable and environmentally acceptable approach to meet the world's growing energy demands, especially in rapidly emerging countries with rising living standards and populations [30]. In this regard, providing sustainable energy alternatives is the most crucial prerequisite. The least important element in determining whether or not solar energy is adopted was found to be its cost. Conversely, in a recent survey done in southern Malawi, 52% of the respondents stated that one of the main benefits of using solar energy for homes was its low cost [31]. Different research populations may be the cause of the differences be-

tween the studies. For example, whereas the prior study involved homes, the present study focused on smallholder enterprises. It is noteworthy that the groups may utilize solar studies differently since they have different needs—one group may use it for household usage, while the other may use it for business.

None of the variables linked to the acceptance or adoption of solar energy had a statistically significant impact, according to the regression analysis results. We blame the study's results on the smaller sample size, which may have reduced the statistical power.

4.4. Relationship among Study Variables

The results of the Pearson correlation analysis indicate a strong positive link between attitudes toward and intentions for using solar energy. The small association coefficient, however, indicates that adoption intention may somewhat decline as sentiments rise. Although it can appear illogical, there could be other variables influencing the link. Furthermore, there is a statistically significant association between attitudes and perceived advantage, indicating that those who have more favorable views would see more benefits from using solar energy. These results underline the need for more study taking into account a variety of characteristics and potential confounding factors, as well as the complexity of factors influencing the desire to embrace solar energy. People who have more positive attitudes about solar energy likely to have somewhat lower intents to embrace solar energy, according to the weak negative correlation value of −0.044.

It is not a dependable result in the population, though, since the absence of statistical significance ($p = 0.452$) suggests that this link may have happened by accident. It is crucial to remember that correlation does not indicate causation, and attitudes and adoption intentions toward solar energy may be influenced by other variables that our investigation did not take into consideration. A bigger sample size or the inclusion of other factors may be required in future studies to fully comprehend the connection between attitudes and adoption intentions in this particular situation.

Pearson correlation showed that there is a weak negative relationship between perceived costs and attitudes towards solar energy adoption and it was not statistically significant. ($p = 0.573$, $r = -0.033$).

The study discovered a significant correlation between the cost of installation and the decision not to use solar energy. The association between attitude and perceived cost is weakly negative, as indicated by the correlation value of −0.033. The p-value, however, is not statistically significant, indicating that variables other than perceived costs may have a greater impact on views on the adoption of solar energy. This is consistent with a previous study that looked into how customer attitudes toward the adoption of wind energy are influenced by perceived costs. The influence of perceived costs on customer willingness to embrace wind energy technology was investigated by the researchers using regression analysis and survey data analysis. Since perceived costs by themselves may

not always correlate with a rejection of solar energy adoption, more investigation and analysis may be required to find additional factors.

Study Limitations

The study was cross-sectional, and this means that the study does not provide findings on how solar energy adoption is determined over time. As such the study findings best reflect the current situation on how solar energy adoption is determined.

While the study findings are reflective of Malawi as a whole the sampling size and location of the study could best reflect Mzuzu city.

Although the regression model was a good fit for the data, the study has focused on only three predictors, which could have an impact on the error of prediction that is to say if more variables could be included in the model there might be more insights.

Research Recommendations

Based on the research findings and conclusions made, the researcher therefore recommends that there is a need to continue with mass media communication on the benefits of using solar energy technology for people especially SMEs owners and runners. It is also recommended that government should create deliberate conditions to make solar energy equipment affordable to many Malawians with low incomes and manufacturing companies should strive to produce durable appliances.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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