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Research Article

The Impact of Rural Electrification on SME Growth in Zambia: Evidence of Kawambwa District

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About Article

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ABSTRACT

This study focused on analyzing the Impact of Rural Electrification on SME Growth in Zambia using data for Kawambwa District. Using qualitative and quantitative methods and a sample size of 50 SMEs, the study aimed to assess the impact of rural electrification on SME revenue, operating costs, and employment. The results showed that rural electrification has a positive impact on SME revenue and Competitiveness. A statistical test run in Chi-Square between electrification and SME revenue yielded a highly significant association between the two variables. ($n = 50$, $\chi^2 (9) = 150.0$ and $p = 0.000$). The study revealed a significant and strong association of the impact of rural electrification on four dependent variables - Bills Reduction, Reliance on Expensive Electricity Sources, Efficient Equipment use and Production Costs Reduction. Regression output yielded R^2 values ranging from 0.58 to 0.96 with all model specifications statistically significant at the $\alpha = 1\%$ level. Rural electrification showed a positive effect on bill reduction, with an estimated coefficient of 0.86 (95% CI: 0.62–4.28). Reliance reduction is particularly strong, with an estimated effect of 0.94 (95% CI: 0.88–0.99), indicating that rural electrification substantially decreases dependence on alternative energy sources. The effect of rural electrification on employment was examined and the results showed that it has a positive impact on employment. The model was statistically significant, $F (1,48) = 111.96$, $p < 0.001$, and explained approximately 70% of the variation in employment outcomes ($R^2 = 0.6999$). Further, it showed that, with electricity, the demand for workers increases from a baseline of 1.33 to 1.40 workers per SME. The study concluded that rural electrification is a catalyst for SME growth. It recommended that the government should expand rural electrification, integrate it with SME support programs, promote educational advancement, monitor employment dynamics, strengthen competitiveness through revenue-based policies, address infrastructure gaps for those without electricity and conduct further research on emerging trends.

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1. INTRODUCTION

1.1. Background of the study

Unlike developing regions, the Western world has long-established rural electrification networks, with nearly universal access to electricity in countries such as the United States, Canada, and those in Western Europe (Lewis & Severnini, 2020; Pellegrin & Tasciotti, 2013). Electrification in rural areas of these nations was largely completed in the mid-20th century, particularly through government initiatives such as the Rural Electrification Act in the U.S passed in 1936 and similar initiatives in Europe post-World War II. This widespread availability of electricity has been a crucial driver of economic development, fostering industrialization, automation and the expansion of small and medium enterprises (Moss & Kincer, 2023). SMEs in rural areas of Western countries benefit from stable electricity, enabling them to implement advanced technologies such as automation, artificial intelligence and high-speed internet-powered operations. Electrification has allowed SMEs in rural Western regions to scale up, contributing to job creation and economic diversification. In the European Union, rural SMEs account for over 50% of employment in some countries, particularly in sectors such as agribusiness, renewable energy, and digital services (Eurostat, 2022).

Small and medium enterprises (SMEs) are a noteworthy driver of economic development, being vital to most economies across the world, particularly in developing and emerging nations (Gherghina. *et al*, 2020). In Nigeria, for instance, SMEs contributed about 48.47% to the national Gross Domestic Product (GDP) in 2013 (Umar *et al.*, 2020). However, a significant barrier to their growth in rural areas is the lack of reliable electricity. Approximately 600 million people in Africa lack access to electricity, hindering the potential of rural SMEs (OECD, 2022). Rural electrification the process of providing electricity to remote and underserved areas has been recognized as a catalyst for economic transformation. For example, in Tanzania, a pilot project led by Energy 4 Impact resulted in an 87% increase in profits among rural businesses and the creation of 214 permanent jobs (Energy 4 Impact, 2025). Despite these potential benefits, the extent to which rural electrification influences SME growth varies and heavily depends on supply reliability. Electricity supply reliability is a key factor in maximization of electrification benefits. Most of the previous research studies have reported that load shedding disrupts production schedules and hampers productivity of firms. As reported by Banda *et al.* (2020), many SMEs are forced to close during load shedding hours, resulting in a drop in sales, reduced turnover, and an inability to meet operating cost.

As of 2024, approximately 42.0% of Zambian households have access to electricity (World Bank, 2024). However, this access is unevenly distributed. While over 75% of urban households in Zambia have access to electricity almost exclusively through the grid less than 12% of rural households have any kind of electricity (World Bank, 2024). This disparity underscores the challenges faced by rural SMEs that rely on electricity for operations. To address this gap, the Zambian government, through the Rural Electrification Authority (REA), has developed the Rural Electrification Master Plan (REMP). The REMP aims to increase rural electricity access rates from a baseline of 3% to 51% by

2030. It identifies and prioritizes 1,217 Rural Growth Centers (RGCs) for electrification using appropriate technologies, including grid extensions, mini-hydro power plants, and solar home systems.

1.2. The problem statement

The statement of the problem acknowledges electricity service as one of the factors, which may have both a direct and indirect impact on small micro-enterprises development (Kariuki, 2016). Despite the importance, contributions and potential of Micro-enterprises to the economy, there are several factors that hinder their establishment and growth. One of the factors, which may contribute to these problems is grid electricity services, because without available and reliable electricity services there is no possibility of utilizing modern electrical appliances, welding kits, and machinery which may pave the way to small and cottage industries. Rural SMEs face the challenge of access to reliable electricity which can impede growth. This challenge limits the contribution of Small and Medium Enterprises (SMEs) to Zambia's economy. Rural areas, including in Kawambwa District of Luapula Province continue to face significant challenges related to electrification which directly affects the growth and sustainability of local businesses. Despite the government's efforts to improve rural electrification through the Rural Electrification Authority (REA) and the Rural Electrification Master Plan (REMP), a significant electricity access gap persists. While urban electrification in Zambia exceeds 80%, rural areas, including Kawambwa, remain underdeveloped with only about 34% of rural households and SMEs having access to electricity (Zambia Monitor, 2024). This disparity limits the ability of SMEs to grow, modernize, and compete effectively in the market. In Kawambwa, most SMEs operate with limited or no access to grid electricity, relying on costly and inefficient alternatives such as diesel generators, solar power or biomass energy sources.

1.3. Research objectives

1.3.1. General and specific objectives

The main objective of this study was to analyze the impact of rural electrification on SME growth in Zambia focusing on Kawambwa District.

1.3.2. Specific objectives

- i. To assess the Impact of Rural Electrification on SME Revenue in Kawambwa District.
- ii. To analyze the Effects of Rural Electrification on SME Operating Costs in Kawambwa District.
- iii. To analyze the Effects of Rural Electrification on SMEs Employment Creation in Kawambwa District.

1.4. Theoretical framework

The Theory of Constraints (Goldratt, 1990) is the theoretical framework settled for by the researcher. This theory is a methodology for identifying the most important limiting factor that stands in the way of achieving a goal and then systematically improving that constraint until it is no longer the limiting factor. This theory was considered as appropriate for this study, in an important manner. The lack of electricity



connections is a constraint to SMEs growth in rural areas. On the other hand, analyzing the impact of rural electrification on SMEs growth tries to probe the successes achieved when the constraint, lack of electricity connectivity is solved.

1.5. Conceptual framework

The interaction of the variables in the study are as represented in the conceptual framework below in figure 1. The rural electrification was the independent variable affecting SME growth measured in three dependent indicators – Revenue, Operating Costs and Employment.

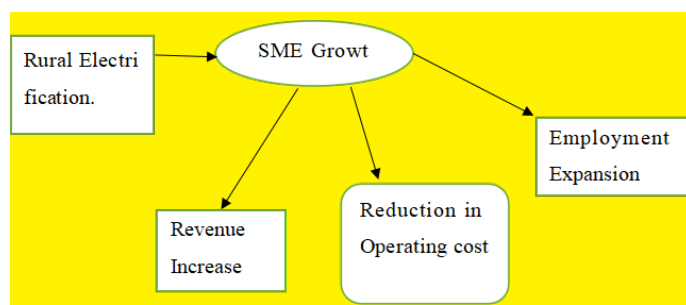


Figure 1. Conceptual framework

1.6. Justification of the study

This study contributes to the existing literature on the impact of rural electrification on SME growth, providing new insights and empirical evidence from the Zambian context. The study's findings will inform policymakers and stakeholders on the effectiveness of rural electrification programs in promoting SME growth and economic development in Zambia. The study's results will provide practical insights for SME owners and managers in Kawambwa District, highlighting the benefits and challenges of rural electrification and its impact on their businesses. By examining the impact of rural electrification on SME growth, this study aims to empower rural communities in Kawambwa District, promoting economic development and improving living standards. The study aligns with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 8 (Decent Work and Economic Growth), by exploring the role of rural electrification in promoting sustainable development in Zambia. Overall, this study aims to provide valuable insights into the impact of rural electrification on SME growth in Zambia, contributing to the development of effective policies and strategies that promote economic development and improve living standards in rural areas.

2. LITERATURE REVIEW

2.1. Overview

The literature review involves the critical analysis of existing research on a specific topic, summarizing and synthesizing key findings to provide context, identify research gaps, and form a foundation for new studies.

2.2. The impact of rural electrification on SME revenue

The revenue a firm generates is an important metric in business and business expansion depends on the levels of revenue

growth. Therefore, the study sought to investigate the impact of rural electrification on SME revenue. As a result of access to electricity, Khurana and Sangita, 2022 found a positive effect on manufacturing output in India and Grimm *et al.* (2011) found a positive effect on firm revenues in Burkina Faso and Ghana, respectively. By contrast, Peters *et al.* (2011); Akpan *et al.* (2013); and Kinda & Loening (2010) found that, when controlling for other factors, electrification does not significantly affect firm performance (measured by profits, business income, and employment growth). This difference in findings can be attributed to the fact that, there are other variables that are significant to SME revenue apart from electricity accessibility. None of these studies was done in Kawambwa District, hence creating a research gap for the current study.

Maleko (2005) carried out a study in Tanzania and sought to find out the effect of the adoption of electricity on the performance of microenterprises. The results revealed that the growth rate of micro-enterprises was noticeably higher in areas with electricity services than in areas without electricity services. Ouma (2013) assessed rural electrification and growth of SMEs in Mbita Town of Tanzania and found a direct link between rural electrification and firm growth. The study used a descriptive research design and surveyed all 280 small and medium enterprises in Town. The study revealed that most SMEs introduced new services as a result of the value addition that was enabled by electrification. However, Peters *et al.* (2011) found that, when controlling for other factors, electrification does not significantly affect firm performance (measured by profits, business income, and employment growth). The contrast in findings can be attributed to differences in availability of other important variables, such as business support through government policy. The current study sought to provide an assessment for Kawambwa District.

Ajibola *et al.* (2021) studied the Impact of Electricity Supply on the Performance of Small and Medium-Scale Enterprises (SMEs) in Nigeria. The findings showed that there is significant impact of electricity supply on the performance of SMEs. However, a study by Maleko (2018) noted a decline and closure of micro-enterprises in the study area at a very low rate. These declines of business were caused by high competition and market saturation. According to Maleko, the introduction of electricity services created more SMEs of the same nature without having a good plan for the markets of their products. This ended up with market saturation. The market saturation caused low turnover, low saving from electricity services and high running costs (Maleko, 2018).

The lack of electricity supply to rural communities in Zambia has significant impacts on the opportunities available to people living in these areas. Lack of access to electricity limits the ability of farmers and small businesses to increase their productivity and income (Haigh, 2023). However, access to electricity comes as an immediate solution to some of the challenges highlighted above.

Carabajal *et al.* (2024) found that SMEs and households connected to solar mini-grids in Kenya and Nigeria experienced a fourfold increase in median incomes, while Beyene *et al.* (2021) reported revenue gains for Ethiopian micro-businesses using solar PV systems. Kirubi *et al.* (2009), studying micro-grids in Kenya,



similarly found electrification raised worker productivity by 100–200 percent and boosted business incomes by 20–70 percent. Akpan *et al.* (2013) investigated micro-enterprises in Nigeria's Niger Delta region, showing that firms in electrified communities were on average 16.2 percent more profitable than those without access, though statistical significance was not always achieved. The failure to achieve universal statistical significance can be attributed to other factors that affect SME revenue.

In a case study of Shiwang'andu district, Banda (2019) examined the effects of a 1 MW small hydropower plant on local businesses. The study revealed a significant increase in business activities, with local entrepreneurs establishing restaurants, bars, and shops that leveraged electricity. These developments diversified income sources and created employment opportunities within the community. Similarly, Walter *et al.* (2025) found that electrification in other rural districts encouraged entrepreneurship, although other researchers, such as World Bank (2019), noted that some communities experienced slower business uptake due to limited access to credit even with electricity access.

2.3. The effects of rural electrification on SME operating costs

Agri-sciences (2021) examined rural SMEs in Hokkaido, Japan, and found that access to reliable electricity significantly reduced operating costs, particularly in agro-processing and small manufacturing businesses. The study recommended expanding rural grid reliability to enhance SME efficiency and competitiveness. Similar results were reported by OECD (2025) observed that rural electrification reduced energy expenditures for SMEs in Tohoku, allowing reinvestment in machinery and labor. However, IEA (2024) noted that SMEs in remote islands experienced smaller cost reductions due to higher transmission fees. IEA's findings show the need to include measures to ensure affordability in electrification initiatives.

Graber (2018) analyzed SMEs in rural Ghana and reported that electrification allowed businesses to replace diesel generators with grid electricity, resulting in a 25–35% reduction in energy-related costs. Dimoso and Kitole (2021) conducted a study on Rural Electrification and Small and Medium Enterprises' (SMEs) Performances in Tanzania and found that rural electrification enhanced SME performance. Similar results were found by OECD (2025), whereas IEA (2024) noted that SMEs relying on high-power machinery saw smaller relative savings due to peak-hour charges. These contradictory findings create a gap for the current study.

Access to reliable electricity is also widely documented as a critical factor in reducing operating costs for small and medium-sized enterprises (SMEs) in Sub-Saharan Africa (Osei-Gyebi & Dramani, 2023). Ngowi *et al.* (2019) conducted a study on the benefits and challenges to productive use of off-grid rural electrification using mini-hydropower in Bulongwa-Tanzania. The study emphasized that, the role of access to electricity in forming and sustaining productive use depends on the specific activities requiring electricity. Carabajal *et al.* (2024) conducted a Social and Economic Impact Analysis of Solar Mini-Grids in Rural Africa. The findings revealed that the use of mini grids

reduced reliance on expensive alternative, hence reducing SME operating costs. Bose *et al.* (2013) found similar results in Bangladesh.

Rural electrification, including both grid extension and decentralized solutions such as solar mini-grids, has shown evidence of lowering SME operating costs substantially. Studies across SSA indicate that SMEs connected to reliable electricity can reduce energy expenses by 25–50%, enabling firms to invest in mechanization, refrigeration, and extended operating hours (UNDP, 2022; Eberhard *et al.*, 2011). For example, SMEs using solar-powered mini-grids in Ghana reported a 30% reduction in energy costs, while in Kenya, businesses in electrified villages experienced savings of approximately 35% (World Bank, 2017; World Bank, 2018).

2.4. The effects of rural electrification on SMEs employment

The impact of rural electrification is self-evident. However, Jimenez (2017) argues that, the realization and size of the long-term effects depend on behavioral considerations at firm level. He notes that, investment decisions may depend on the quality and reliability of electricity, and on the costs of coping with energy scarcity. Magbondé *et al.* (2025) examined the impact of rural electrification on economic development in Senegal. The study found that access to reliable electricity enables SMEs to grow, innovate, and increase labor demand, particularly through integration into local economic strategies such as Rural Productivity Zones. These findings are consistent with (Lenz *et al.*, 2017), who emphasized that electrification supports employment creation in agro-processing and rural marketing enterprises.

Clark (2025) examined the role of electrification in improving employment opportunities for women and youths in Sub-Saharan Africa (SSA). The study found that electrified SMEs in food production, hospitality, and retail benefited from access to refrigeration, lighting, and digital payment systems, which created new jobs for the target population in the study. These findings align with FAO and ILO (2021), who highlighted similar benefits for rural SME employment. On the other hand, (Dinkelman, 2011) who did research in South Africa found that, some electricity projects provided power supplies too small for industrial use, and there is little evidence of SME employment demand created by such projects.

Walter *et al.* (2025) examined electrification's effect on rural retail businesses in Zambia. They found that electrified shops could operate cold storage units for perishable goods, reporting a 20% increase in profits. Barbershops, welding services, and small-scale manufacturing businesses also flourished, contributing to employment generation. Recommendations included expanding electrification and supporting SME access to affordable financing. Similar results were reported by Mele (2020), who noted a 30% increase in women-led SMEs in electrified areas. Contrastingly, Rural Electrification Authority (2021) highlighted that high costs and unreliable power supply remain barriers to universal SME benefits including employment demand for SMEs.

Haney *et al.* (2019). investigated SMEs in rural Copperbelt and found that enterprises involved in carpentry, tailoring, and



welding experienced significant productivity gains following access to electricity, which allowed them to operate electric-powered machinery and extend business hours, increasing the demand for skilled and semi-skilled workers. The study recommended that electrification initiatives be combined with SME training and financial support to fully exploit employment potential, Haney *et al.* (2019). These results were consistent with International Labour Organization (ILO) (2025), who reported that solar mini-grids improved SME operational efficiency and created new employment opportunities in remote Copperbelt communities. Contrastingly, Odofo (2020) observed that SMEs in areas with intermittent electricity faced reduced employment growth despite access to power.

3. METHODOLOGY

This section presented the research methodology, detailing the research design, target population, sampling design, sample size determination, data collection methods, data analysis, triangulation, limitations, and ethical considerations.

3.1. Research design

This study employed mixed method research design, which is commonly used to provide a comprehensive understanding of the characteristics, behaviors and conditions of a specific population or phenomenon (Nwogu, 2001). As Nwogu (2001) describes mixed method research as an approach used to collect information from a sample or population that possesses knowledge relevant to the study's objectives. Maxwell (2012) further explains that mixed method research involves analyzing data from selected samples through means such as telephone or personal interviews. Johnson *et al.* (2007) define mixed method research as an in-depth investigation of an individual, group, organization, event, or phenomenon, incorporating multiple data sources such as interviews, observations, documents, and artifacts. The objective is to gain a thorough understanding of the case in question rather than generalizing findings. Mixed method research is particularly useful for exploring complex topics, identifying patterns, and formulating explanations or theories. It is especially beneficial when literature on a subject is limited or when the topic requires exploration within its natural setting. The results are typically presented in a narrative format, detailing the research process, data analysis and interpretations.

3.2. Sampling design and data collection

The study used simple random sampling to select participants, ensuring that all members of the population had an equal opportunity of being included in the sample (Martínez-Mesa *et al.*, 2016). Data was collected through questionnaires. The questionnaire utilized structured and unstructured questions to allow respondents to provide detailed responses.

The study employed different sampling techniques, following Rubin and Babbie's (2005) classification of probability, non-probability, and mixed sampling strategies. Specifically, purposive sampling, a non-probability method, was used to select participants who possessed relevant knowledge and experience regarding rural electrification (Etikan *et al.*, 2016). In addition, simple random sampling, a probability method,

was employed to ensure that other participants from the target population had an equal chance of being selected, minimizing selection bias (Kothari, 2010). Sample size referred to the number of items selected from the population to constitute the sample, determining how many units were surveyed and interviewed (Kothari, 2010). Larger samples provided more reliable results than smaller ones. Accordingly, the study used a sample size of fifty (50) participants. Though the small sample size may compromise findings, the use of a larger sample size was not possible due to time and financial resources limitations.

3.3. Model and variable specification

The study employed a multivariate linear regression model to examine the impact of rural electrification on SME growth. The model was adopted from Khan *et al.* (2018), who studied the effects of rural electrification on SME development in Pakistan. The regression equation was specified as:

$$Y = \beta_0 + \beta_1 (\text{Rural Electrification}) + \beta_2 (\text{Reliability of Electricity Supply}) + \beta_3 (\text{Affordability of Electricity Supply}) + \epsilon$$

In this model, the dependent variables included SME revenue growth, SMEs operating cost, employment opportunities and SME profitability. The independent variable was rural electrification, while control variables included the reliability and affordability of electricity supply. β_0 represented the constant term, $\beta_1 - \beta_3$ were the coefficients for the independent and control variables, and ϵ was the error term.

Regression Equation:

$$Y = \beta_0 + \beta_1 (\text{Rural Electrification}) + \beta_2 (\text{Reliability of Electricity Supply}) + \beta_3 (\text{Affordability of Electricity Supply}) + \epsilon$$

Dependent Variables:

- i. SME revenue growth
- ii. SME operating costs
- iii. Employment opportunities.

Y = Dependent variable (SME revenue growth, SME operating cost and SME demand for employment.)

β_0 = Constant term

β_1 = Coefficient of rural electrification

β_2 = Coefficient of reliability of electricity supply

β_3 = Coefficient of affordability of electricity supply

ϵ = Error term

Independent Variable:

Rural electrification

Control Variables:

- i. Reliability of electricity supply
- ii. Affordability of electricity supply

4. RESULTS AND DISCUSSION

This section presents the results and discussion based on the study findings. The study adopted suitable variables under each specific objective, and the adopted variables were used to run statistical tests in order to ascertain statistical significance of the data collected. It also included demographic information which are presented first in the section.

4.1. Demographic profile of respondents

Gender was among the demographic features of respondents. Under this demography, results showed that majority of the respondents were male (28) representing 56% of the



respondents and (22) 44% were female. The table below shows gender distribution.

Table 1. Gender distribution of respondents.

	frequency	percent	Cumulative	
			frequency	Percent
MALE	28	56.0	28	56.0
FEMALE	22	44.0	50	100.0
	50	100.0		

Table 2. Type of business distribution of respondents.

	frequency	percent	cumulative	
			frequency	percent
RETAIL	8	16.0	8	16.0
RESTAURANT	10	20.0	18	36.0
SALON & BARBERSHOP	13	26.0	31	62.0
PHOTOCOPYING & PRINTING	13	26.0	44	88.0
OTHERS	6	12.0	50	100.0
	50	100.0		

the relationship between revenue levels and competitiveness among the sampled entities. The cross-tabulation revealed a perfectly aligned distribution: each revenue category corresponded exclusively to a single competitiveness level. Specifically, all entities in revenue level 1 were classified under competitiveness level 1, those in revenue level 2 under competitiveness level 2, and so forth, culminating in revenue level 4 aligning entirely with competitiveness level 4.

The Pearson chi-square statistic was calculated as χ^2 (9)

4.1.2. Business type

The Type of Business was also part of the demography, and it was established that majority of SMEs who participated in the research were those in Salon and Barbershop and Photocopying, Printing and other related services, both at 26%. Restaurant business followed closely with 20% of respondents while retail had 16% and others had 12% of the respondents.

4.2. Impact of rural electrification on SME revenue in kawambwa district

A chi-square test of independence was conducted to examine

= 150.0000 with a p-value of 0.000, indicating a highly significant association between the two variables. This result suggests that the observed distribution is not due to random chance and that revenue level is a strong predictor of competitiveness level within this dataset. These findings imply a direct and systematic relationship between financial performance and competitive standing, reinforcing the hypothesis that increased revenue is associated with higher competitiveness.

Table 3. Revenue and competitiveness

Revenue	Competitiveness 1	Competitiveness 2	Competitiveness 3	Competitiveness 4	Total
1	2 (100.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (100.00%)
2	0 (0.00%)	4 (100.00%)	0 (0.00%)	0 (0.00%)	4 (100.00%)
3	0 (0.00%)	0 (0.00%)	7 (100.00%)	0 (0.00%)	7 (100.00%)
4	0 (0.00%)	0 (0.00%)	0 (0.00%)	37 (100.00%)	37 (100.00%)
Total	2 (4.00%)	4 (8.00%)	7 (14.00%)	37 (74.00%)	50 (100.00%)

Pearson $\chi^2(9) = 150.0000$ $Pr = 0.0000$

4.3. Effects of rural electrification on SME operating costs in kawambwa district

The multivariate linear regression model was applied to analyze the data. The regression analysis demonstrated that the models fit the data well, with R-squared values ranging from 0.58 to 0.96 and all model specifications statistically significant at the 1% level. Rural electrification has a positive and significant effect on bill reduction, with an estimated coefficient of 0.86 (95% CI: 0.62–4.28). Reliance reduction is particularly strong, with an

estimated effect of 0.94 (95% CI: 0.88–0.99), indicating that rural electrification substantially decreases dependence on alternative energy sources. Additional factors also exhibited positive and significant coefficients, including an effect of 0.59 (95% CI: 0.45–0.84) and a larger effect of 2.03 (95% CI: 1.49–2.58). These results provide consistent evidence that rural electrification generates meaningful economic and social benefits.

Our analysis showed that rural electrification strongly improves SME growth. The models explained between 58%



and 96% of the variation in SME operating costs reduction, and the effects are statistically reliable. Electrification reduces energy bills by about 0.86 units on average, and it almost completely eliminates reliance on alternative sources,

reducing it by 0.94 units. Taken together, the evidence made it clear that rural electrification provides significant cost savings, reduces dependence on substitutes, and delivers strong overall gains.

Table 4. Rural electrification and other four outcome variables

Equation	Obs	Parms	RMSE	R-sq	F	P
Energy_Bill_Reduction_K	50	2	0.5818984	0.6885	106.1025	0.0000
Reliance Reduction	50	2	1.1913477	0.9582	1099.104	0.0000
Equipment_Efficiency_Score	50	2	0.4444666	0.6225	79.15734	0.0000
Production_Cost_Reduction	50	2	0.649075	0.0883	4.646779	0.0362

Table 5. Rural electrification and other four outcome variables

Dependent Variable	Predictor	Coefficient (B)	Std. Error	t-value	p-value	95% Confidence Interval
Energy Bill Reduction (K)	Rural Electrification	-8.880	0.867	-10.30	.000	[-10.618, -7.143]
	Constant	4.765	0.242	19.68	.000	[4.279, 5.252]
Reliance Reduction (m)	Rural Electrification	-1.382	0.138	-10.01	.000	[-1.659, -1.105]
	Constant	1.591	0.168	9.45	.000	[1.253, 1.929]
Equipment Efficiency (e)	Rural Electrification	1.583	0.058	27.06	.000	[1.465, 1.700]
	Constant	2.811	0.071	39.43	.000	[2.668, 2.955]
Production Cost Reduction (m)	Rural Electrification	0.207	0.065	3.19	.003	[0.078, 0.337]
	Constant	2.574	0.093	27.78	.000	[2.387, 2.760]

4.4. Effects of rural electrification on SMEs employment increase in kawambwa district

The regression analysis was conducted to examine the effect of access to electricity on employment outcomes using 50 observations. The model was statistically significant, $F(1,48) = 111.96$, $p < 0.001$, and explained approximately 70% of the variation in employment outcomes ($R^2 = 0.6999$).

The results showed that access to electricity has a positive and statistically significant effect on employment outcomes ($\beta = 1.40$, $t = 10.58$, $p < 0.001$). This means that having access to electricity is associated with an increase to about 1.40 employees, compared to those without electricity at 1.33 employee demand. The 95% confidence interval for this effect ranges from 1.13 to 1.66, confirming the robustness of the result. The constant term

was also significant ($\beta = 1.33$, $p < 0.001$), indicating that even without electricity access, the baseline employment outcome is 1.33 units. Since the p-value is < 0.05 , we reject the null hypothesis and conclude that access to electricity significantly improves employment outcomes.

Table 6. Access to electricity on employment outcome using stata

Source	SS	df	MS
Model	24.3712821	1	24.3712821
Residual	10.4487179	48	0.217681624
Total	34.82	49	0.710612245

Table 7. Coefficients

Predictor	B(Unstandardized Coefficient)	Std. Error	t-value	Significance (p)	95% Confidence Interval
(Constant)	1.333	0.095	14.000	.000	[1.141, 1.526]
Access to Electricity	1.397	0.132	10.580	.000	[1.132, 1.663]

4.5. Discussion

The study adopted three (3) specific objectives; assessing the Impact of Rural Electrification on SME Revenue, operating Costs and Employment in Kawambwa District.

The study adopted indicators of SME revenue growth. A chi-square test of independence was conducted to examine the

relationship between revenue levels and competitiveness among the sampled entities. The Pearson chi-square statistic was calculated as $\chi^2(9) = 150.0000$ with a p-value of 0.000, indicating a highly significant association between the two variables. This result suggests that the observed distribution was not due to random chance and that revenue level is a strong predictor of



competitiveness level within this dataset. These findings were consistent with Rud (2012) and Grimm *et al.* (2011) who also found a positive effect of rural electrification on firm revenues in Burkina Faso and Ghana, respectively. By contrast, Peters *et al.* (2011); Akpan *et al.* (2013); and Kinda and Loening (2010) found that, when controlling for other factors, electrification does not significantly affect firm revenue.

On Rural Electrification impact on SME operating Cost, the regression analysis of parameters used under this objective demonstrated that the models fit the data well, with R-squared values ranging from 0.58 to 0.96 and all model specifications statistically significant at the 1% level. It showed that Rural electrification had a positive and significant effect on bill reduction, with an estimated coefficient of 0.86 (95% CI: 0.62–4.28). Reliance reduction was particularly strong, with an estimated effect of 0.94 (95% CI: 0.88–0.99), indicating that rural electrification substantially decreases dependence on alternative energy sources. Additional factors also exhibited positive and significant coefficients, including an effect of 0.59 (95% CI: 0.45–0.84) and a larger effect of 2.03 (95% CI: 1.49–2.58). These results provide consistent evidence that rural electrification generates meaningful economic and social benefits. These finding were in line with Sato (2015) who found that access to reliable electricity significantly reduced operating costs, particularly in agro-processing and small manufacturing businesses and Tanaka (2016), who observed that rural electrification reduced energy expenditures for SMEs in Tohoku. Contrastingly, Saito (2017) noted that SMEs in rural areas experienced smaller cost reductions due to higher transmission fees.

Further analysis explored the relationship between access to electricity and employment outcomes. The regression analysis conducted examined the effect of access to electricity on employment outcomes using 50 observations. The model was statistically significant, $F(1,48) = 111.96$, $p < 0.001$, and explained approximately 70% of the variation in employment outcomes ($R^2 = 0.6999$).

The results showed that access to electricity had a positive and statistically significant effect on employment outcomes ($\beta = 1.40$, $t = 10.58$, $p < 0.001$). This means that having access to electricity is associated with an increase of about 1.40 units in employment outcome. The findings were consistent with Magbondé *et al.* (2025) who examined the impact of rural electrification on economic development in Senegal. The study found that access to reliable electricity enabled SMEs to grow, innovate, and increase labor demand, particularly through integration into local economic strategies such as Rural Productivity Zones. The study recommended incorporating energy access into rural development planning to enhance employment outcomes. These findings were consistent with (Lenz *et al.*, 2017), who found that electrification supports employment creation in agro-processing and rural marketing enterprises. However, electrification focused on roll-out to household targets and with capacity that is too small to stimulate even mid-size manufacturing or service enterprises provides only a small net effect on employment, primarily through a labour supply channel (Dinkelman, 2011).

5. CONCLUSION

This study explored the demographic, socioeconomic, and infrastructural factors influencing SME performance particularly access to electricity through rural electrification in Kawambwa District.

The core of the study focused on the effects of rural electrification on SME outcomes. Regression analysis demonstrated that electrification significantly reduces operating costs, lowers reliance on alternative energy sources, and improves overall welfare. These effects were statistically robust, with models explaining a substantial portion of the variation in SME behavior. The findings affirm the transformative role of electricity access in enhancing business efficiency and household stability.

Further chi-square analysis confirmed a strong association between SME revenue and competitiveness, indicating that financial performance is closely tied to market positioning. Access to electricity was also significantly linked to improved employment outcomes, with electrified individuals showing more diverse and favorable job prospects. Nonetheless, correlation tests revealed no meaningful relationships between employment growth, skill acquisition, and labor demand, suggesting that these variables may be influenced by other external factors not captured in this dataset.

Overall, the study provides compelling evidence that rural electrification is a catalyst for economic and social development. It does not only improve SME performance but also contributes to better employment outcomes and household welfare. These insights underscore the importance of expanding energy infrastructure as a strategic priority for rural development and inclusive growth.

RECOMMENDATIONS

- *Expand rural electrification programs:* Given the strong and statistically significant impact of electricity access on SME performance, employment outcomes, and household welfare, it is recommended that rural electrification initiatives be scaled up. Priority should be given to underserved areas where infrastructure gaps continue to limit economic potential.

- *Integrate electrification with SME development support:* Electrification alone is transformative, but its benefits can be amplified when paired with targeted SME support such as access to financing, training, and market linkages. Development programs should bundle energy access with business development services to maximize competitiveness and revenue growth.

- *Promote educational advancement among rural populations:* The observed link between marital status and education, particularly the higher educational attainment among unmarried individuals, suggests that education may influence life choices and economic mobility. Investment in adult education and vocational training, especially for older and married individuals, could help bridge gaps in opportunity.

- *Monitor and evaluate employment dynamics post-electrification:* While electricity access correlates with improved employment outcomes, the lack of significant relationships between new hires, skill acquisition, and labor demand points to a need for more nuanced workforce planning. Future programs should include mechanisms to track how electrification affects



job creation, skill development, and labor market shifts over time.

- *Target competitiveness through revenue-based interventions:* The perfect alignment between revenue levels and competitiveness underscores the importance of financial performance in determining SME market strength. Policies that enhance revenue such as tax incentives, procurement inclusion, and digital payment systems can directly improve competitiveness.

- *Conduct further research on marginal trends:* Future studies with larger samples or longitudinal designs could clarify these trends and inform more targeted interventions.

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