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Assessing the Effectiveness of Renewable Energy Integration on Business Growth: A Case Study of SMEs in Lusaka Business Centre

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Abstract

This study assessed the effectiveness of renewable energy integration in supporting business growth among small and medium enterprises (SMEs) operating within Lusaka Business Centre, guided by the Sustainable Livelihoods Framework which considers renewable energy as both a physical and natural capital asset enhancing productivity and business resilience. A case study research design was employed to enable an in-depth exploration of SME experiences, combining both quantitative and qualitative approaches. The target population consisted of SME owners, managers, renewable energy providers, and institutional actors, with a purposive sample of fifty participants, including forty-five SME owners/managers and five key informants. Data were collected using structured questionnaires to quantify adoption trends, operational impacts, and energy cost savings, supplemented by semi-structured interviews and document reviews to capture nuanced perspectives on technology effectiveness and limitations. Quantitative data were analyzed using descriptive statistics including frequencies and percentages, while qualitative data underwent thematic analysis to identify recurring patterns and cross-validate findings. Results indicate high adoption of solar photovoltaic systems (84.4 percent) and hybrid solar–diesel systems (22.2

percent), with 66.6 percent of SMEs reporting that the technology is suitable or very suitable for their operational needs. Renewable energy met 25–50 percent of energy requirements for 40.0 percent of SMEs, and 62.2 percent perceived systems as more reliable than the national grid. Cost reductions were observed, with 35.6 percent reporting 10–20 percent monthly savings, 22.2 percent achieving 21–30 percent, and 15.6 percent saving above 30 percent. Positive business outcomes included improved operational continuity (68.9 percent experienced reduced downtime), enhanced staff productivity (71.1 percent), increased customer service performance (66.6 percent), greater competitiveness (71.1 percent), and higher revenue (68.9 percent reporting positive or very positive growth). However, 51.1 percent rated installation as expensive, 52.2 percent identified limited technical expertise as a barrier, and 75.6 percent reported challenges in accessing finance, highlighting structural and operational constraints. The study concludes that renewable energy integration significantly contributes to SME resilience, operational efficiency, and business growth, while recommending policy incentives, affordable financing, and technical training to enhance adoption and sustainability.

Keywords: Renewable Energy, Small and Medium Enterprises, Business Growth, Solar Power, Energy Reliability, Operational Cost Reduction, Lusaka Business Centre

1. Introduction

1.1 Background

Renewable energy integration involves incorporating clean and sustainable sources such as solar, wind, hydro, and biomass into existing energy systems to reduce reliance on fossil fuels (IRENA, 2019) [6]. For small and medium enterprises (SMEs), access to reliable, cost-effective, and sustainable energy is essential for operational efficiency, growth, and profitability. SMEs form the backbone of many economies, contributing significantly to employment and income generation, particularly in developing countries (UNCTAD, 2018) [22]. Yet, energy poverty continues to limit their potential, making renewable energy technologies (RETs) a promising alternative to support SME resilience and sustainability.

Globally, the transition toward renewable energy has been accelerated by climate change concerns, energy insecurity, and sustainable development goals. The Paris Agreement (2015) [16] urged countries to reduce greenhouse gas emissions and promote clean energy. Investments in renewable technologies reached USD 495 billion in 2022, with solar and wind leading the market (IRENA, 2023) [8]. Firms worldwide are adopting renewable energy to lower costs and achieve environmental, social, and governance (ESG) targets, which enhances competitiveness in both developed and emerging markets (Bocken *et al.*, 2016; Zhang *et al.*, 2021) [3, 25].

In Africa, renewable energy adoption has gained momentum as governments seek to close energy access gaps and foster industrialization. Despite vast solar and hydropower potential, around 600 million Africans remain without electricity (IEA, 2019) [5]. Initiatives like the Africa Renewable Energy Initiative (AREI, 2016) [1] aim to add 10 GW of renewable capacity by 2025. Research in Kenya and South Africa shows that RET adoption among SMEs reduces electricity costs and supports microeconomic development (Ouedraogo, 2017) [15]. However, many African SMEs face energy insecurity due to financing constraints, inconsistent policies, and weak infrastructure.

Sub-Saharan Africa experiences the highest global energy poverty, with SMEs facing intermittent supply, high tariffs, and limited modern energy access (Blimpo & Cosgrove-Davies, 2019) [2]. In Nigeria, frequent power outages compel SMEs to rely on costly diesel generators, reducing productivity and profits (Okoye & Oranekwu-Okoye, 2018) [14]. Conversely, in Rwanda and Ethiopia, donor-supported solar initiatives have enabled urban SMEs to save costs and extend business hours (Martin & Felix, 2020) [10].

Zambia faces a similar energy challenge. Despite hydro and solar potential, frequent load shedding due to low reservoir levels disrupts SME operations, particularly in Lusaka, leading to revenue losses (ZESCO, 2020) [24]. Reliable electricity is among the top five growth constraints for SMEs (Tembo & Mulenga, 2021) [24]. The National Energy Policy (2019) promotes energy diversification and renewable integration (Ministry of Energy, 2019) [11], complemented by programs such as the Beyond the Grid Fund for Zambia (REEEP, 2021) [17].

Despite these interventions, renewable energy adoption among Lusaka SMEs remains limited and under-researched. Most studies focus on households or large industries, leaving a gap in understanding SME-specific impacts. While some evidence suggests RETs reduce costs and foster growth, high installation costs and technical limitations can hinder adoption (Mwanza & Lungu, 2022) [12]. This study seeks to assess the effectiveness of renewable energy integration on SME growth in Lusaka Business Centre.

1.2 Statement of the Problem

Despite policy efforts promoting renewable energy adoption, Zambian SMEs continue to face severe energy constraints that hinder growth and competitiveness. Inconsistent power supply and high operational costs remain major barriers, forcing many businesses in Lusaka to depend on costly, polluting diesel generators that reduce profit margins and scalability (ZESCO, 2020; Tembo & Mulenga, 2021) [24, 20]. Although the National Energy Policy (2019) emphasizes renewable integration, a gap persists between policy intent and implementation (Ministry of Energy, 2019)

[11]. Most studies have focused on rural electrification or large industries, neglecting urban SMEs (Mwanza & Lungu, 2022) [12]. The effectiveness of renewable energy technologies in supporting SME growth within urban centers remains unclear. This study therefore examines how renewable energy integration influences business growth among SMEs in Lusaka Business Centre.

1.3 Objectives

1.3.1 General Objective

To assess the effectiveness of renewable energy integration in promoting business growth among small and medium enterprises in Lusaka Business Centre.

1.3.2 Specific Objectives

1. To analyze the types of renewable energy technologies adopted by small and medium enterprises in Lusaka Business Centre.
2. To assess the effectiveness of renewable energy technologies adopted by SMEs in Lusaka Business Center.
3. To determine the limitations associated with renewable energy integration in supporting the growth of small and medium enterprises in Lusaka Business Centre.

1.4 Research Questions

1. What types of renewable energy technologies are adopted by small and medium enterprises in Lusaka Business Centre?
2. How effective are the renewable energy technologies adopted by small and medium enterprises in Lusaka Business Centre?
3. What are the limitations associated with renewable energy integration in supporting the growth of small and medium enterprises in Lusaka Business Centre?

1.5 Theoretical Framework

This study adopts the Sustainable Livelihoods Framework (SLF), developed by DFID and refined to address energy access, sustainability, and business resilience (Scoones, 2015; Kamruzzaman & Das, 2020) [18, 9]. The SLF views livelihoods as outcomes of interactions among five forms of capital human, social, physical, financial, and natural shaped by institutional and policy contexts. Renewable energy, as both physical and natural capital, enhances SME productivity, reduces costs, and mitigates vulnerabilities. For SMEs in Lusaka, where unreliable electricity constrains operations (Tembo & Mulenga, 2021) [20], SLF emphasizes how sustainable resources and supportive institutions improve outcomes. It also integrates policy and institutional dimensions, enabling assessment of how renewable energy technologies and enabling environments jointly drive SME growth and resilience (Han *et al.*, 2022) [4].

2. Literature Review

2.1 Types of Renewable Energy Technologies Adopted by SMEs

Globally, renewable energy adoption among small and medium enterprises (SMEs) has accelerated as firms seek cost efficiency, energy security, and environmental sustainability. Solar photovoltaic (PV), biomass, and wind technologies dominate due to scalability and declining installation costs. The International Renewable Energy Agency (IRENA, 2021) [7] reports that SMEs are central to decentralized clean energy deployment, particularly in solar

markets. Zhang *et al.* (2019) found that Chinese SMEs adopting solar PV achieved significant cost reductions, driven by government incentives and regulatory clarity. Sharma and Ghoshal (2020) observed similar patterns in India, where leasing and pay-as-you-go models improved accessibility. D'Amato and Falcone (2019) add that SMEs integrating renewable energy alongside environmental certification achieved superior competitiveness and innovation performance. Collectively, these studies confirm that SME adoption is shaped by institutional support, affordability, and sustainability orientation.

Regionally, Sub-Saharan Africa has witnessed growing SME investment in renewable energy, motivated more by survival than environmental goals. Widespread grid unreliability and high tariffs have made solar PV the most practical option (Onyeji *et al.*, 2020). Mutua and Karanja (2019) found that agribusiness SMEs in Kenya adopted solar dryers and pumps to reduce post-harvest losses and stabilize production. Tumwebaze and Mbabazi (2021) reported that Ugandan SMEs using solar PV cut operational costs by 30% and improved energy reliability by over 50%, while Adewuyi and Awolusi (2021) highlighted strong adoption among Nigerian ICT firms seeking uninterrupted power for digital infrastructure. Despite these successes, adoption remains constrained by limited access to credit, weak maintenance support, and inadequate technical capacity. The African Development Bank (2021) notes that scaling up requires gender-sensitive financing, quality assurance, and stronger public-private partnerships to strengthen supply chains and training ecosystems.

In Zambia, renewable energy adoption among SMEs has become increasingly relevant amid power shortages and rising grid tariffs. Chitonge and Chanda (2019) found that solar PV dominates in retail, hospitality, and agro-processing sectors, providing reliable energy for lighting and refrigeration. Similarly, Mwanza and Kalaluka (2021) showed that solar adoption improved productivity and reduced electricity bills by up to 40%, though affordability remains a major constraint. Simukonda and Phiri (2020) observed growing use of solar-powered irrigation and dryers among agribusiness SMEs, supported by donor-funded programs like the Sustainable Energy for Rural Communities initiative. Mwale and Zulu (2023) revealed that ICT-based SMEs in Lusaka increasingly use solar systems to power servers and communication tools, enhancing operational resilience and customer satisfaction. However, regulatory complexity, limited financing instruments, and insufficient technical expertise continue to impede broader uptake. Addressing these barriers through flexible financing, capacity-building, and policy alignment will be essential for accelerating SME-led renewable energy adoption in Zambia.

2.2 The Effectiveness of Renewable Energy Technologies Adopted by SMEs

Globally, renewable energy technologies particularly solar photovoltaic (PV), wind, and bioenergy systems have proven effective in improving SME performance through reduced energy costs, enhanced reliability, and greater competitiveness. IRENA (2021) ^[7] reports that firms integrating solar PV achieve up to 40 percent savings on energy expenditure, with notable improvements in productivity and uptime. Sovacool *et al.* (2022) found that SMEs adopting decentralized systems recorded consistent

operational gains due to lower downtime and improved autonomy. Segura *et al.* (2023) observed that solar projects enhanced return on investment and resilience in European SMEs, while Al-Shahrani *et al.* (2024) highlighted that IoT-enabled renewable systems further boost efficiency through real-time monitoring and predictive maintenance. These findings collectively confirm that renewable technologies enhance firm-level sustainability and profitability, though their effectiveness depends on financing, technical literacy, and enabling policy environments.

Regionally, evidence from Sub-Saharan Africa shows that renewable energy adoption substantially improves SME productivity and resilience amid chronic grid unreliability. Eshun and Amoako (2021) found that solar and biomass systems reduced SMEs' monthly energy costs by 38 percent and increased profits by 15 percent across Ghana, Kenya, and Tanzania. Osei and Quartey (2020) reported a 22 percent rise in production among Ghanaian SMEs using mini-grids, driven by reduced power interruptions. Kirubi *et al.* (2019) documented a 30 percent extension in business operating hours in Kenya and Uganda, demonstrating that reliable renewable access fosters revenue expansion. Similarly, Akinwale and Ogundari (2022) observed that Nigerian SMEs under electrification programs achieved 31 percent cost reductions and expanded formal employment. Across these studies, renewable energy's effectiveness hinges on integration into core operations, availability of maintenance services, and access to flexible finance.

In Zambia, renewable energy effectiveness among SMEs has been closely linked to its ability to mitigate energy insecurity and support productivity. Mwila and Kaoma (2023) found that 64 percent of Lusaka SMEs using solar energy increased operating hours by at least three hours per day, with average profit gains of 22 percent. Phiri and Munthali (2021) reported that mini-grid users reduced energy expenditure by 35 percent and raised production output by 28 percent. Banda and Chansa (2022) observed that market traders employing solar lighting achieved income growth of 15 percent, particularly among women entrepreneurs, while Zulu and Mulenga (2023) demonstrated that solar-powered SMEs reduced downtime by 30 percent and improved order fulfillment rates. Collectively, these studies affirm that renewable technologies enhance operational resilience, profitability, and social inclusion, though their impact is constrained by high initial costs, low-quality imports, and inadequate technical capacity.

Overall, the literature confirms that renewable energy technologies deliver measurable benefits for SMEs through cost savings, productivity gains, and improved energy reliability. Yet, effectiveness remains contingent on three interacting factors: technology quality and suitability, institutional and financial support, and enterprise-level technical competence. Strengthening these dimensions can maximize the transformative potential of renewable energy for SMEs in Lusaka and similar urban economies.

2.3 Limitations of Renewable Energy Integration in Supporting SME Growth

Globally, the adoption of renewable energy technologies (RETs) among SMEs has expanded in response to rising energy costs, climate concerns, and sustainability goals. Solar PV, wind turbines, biomass digesters, and small hydro systems provide cost-effective alternatives to grid power while enhancing energy autonomy. However, limitations

persist. IRENA and ILO (2021) note that SMEs often lack technical expertise and rely on decentralized energy projects where policy incentives, such as feed-in tariffs, are critical for adoption. Zhang *et al.* (2019) found in China that while solar PV reduced energy costs by 24%, institutional support and clear regulatory frameworks were decisive in sustaining usage. Sharma and Ghoshal (2020) in India highlighted knowledge barriers and limited access to technical maintenance, which undermined long-term system functionality. Similarly, Tait *et al.* (2017) reported that SMEs in Brazil, Vietnam, and South Africa faced high upfront costs and insufficient financing, which constrained adoption despite energy security benefits. These studies emphasize that global RET adoption among SMEs is contingent on financing, technical capacity, policy clarity, and digital infrastructure for system monitoring.

Regionally, in Sub-Saharan Africa, renewable energy integration is shaped by chronic grid unreliability and infrastructural constraints. Muriithi and Ondiba (2021) observed that 68% of Kenyan SMEs using solar PV sustained efficiency improvements over two years, but post-installation maintenance gaps threatened long-term performance. Akuffo and Brew-Hammond (2020) reported that hybrid solar-biomass systems in Ghana enhanced energy reliability and revenues by 23%, yet sustainability depended on spare-part availability, training, and financing. Nuhu and Nzilano (2022) found in Tanzania that only 50% of SMEs achieved full operational sustainability due to technical malfunctions and lack of repair services. AfDB and SEFA (2019) noted that 20% of renewable systems across 15 African countries remained functional after five years, underscoring the importance of installer accreditation, certification standards, and SME-targeted financing. Collectively, regional evidence shows that while RETs improve productivity and resilience, systemic and institutional limitations significantly constrain long-term effectiveness.

Locally, in Zambia, renewable energy adoption among SMEs faces similar challenges. Kalinda and Simpungwe (2020) found that although 72% of SMEs in Lusaka and Kitwe initially improved energy reliability, only 38% maintained system performance after 18 months due to irregular maintenance and weak technical capacity. Chilufya and Chanda (2021) noted that rural SMEs using hybrid mini-grids experienced operational gains, yet system failures and lack of local repair services undermined sustainability. Mulenga and Hantuba (2022) reported that while solar PV reduced electricity costs by 25%, inadequate after-sales support and ad hoc system repairs shortened lifespan. Chomba and Sinkamba (2023) highlighted that collective maintenance schemes improved long-term functionality, but Tembo and Lungu (2024) ^[21] observed that many SMEs discontinued use within 12–18 months due to poor installation practices and vendor accountability gaps. Zulu and Banda (2018) emphasized that Zambia's policy framework lacks SME-specific provisions for financing, technical support, and maintenance, limiting RET sustainability.

Overall, global, regional, and local evidence indicates that while renewable energy technologies can enhance SME performance, their long-term effectiveness is constrained by financial barriers, technical skills deficits, inadequate maintenance infrastructure, and weak institutional support. Addressing these limitations requires integrated approaches

combining financing mechanisms, technical training, policy enforcement, and robust service networks to ensure that renewable energy not only supports short-term productivity but also enables sustainable SME growth.

2.4 Establishment of Research Gap

The reviewed literature reveals significant advancements in understanding the role of renewable energy integration in supporting SME development globally, regionally, and locally. However, several critical research gaps remain. Firstly, most global studies emphasize general adoption trends and technological drivers but offer limited insight into how these apply within informal or resource-constrained SME environments such as Lusaka Business Centre. Secondly, while regional and Sub-Saharan African research highlights infrastructural and policy limitations, it often lacks sector-specific analysis of SME experiences and excludes micro-enterprises that dominate local economies. Thirdly, although some local Zambian studies address access to renewable energy, they tend to focus on households or rural settings, with minimal emphasis on urban SMEs or their specific growth trajectories. Furthermore, there is limited empirical evidence linking renewable energy use to quantifiable business outcomes such as income growth, job creation, or operational efficiency in the Zambian context. Lastly, the nuanced limitations technical, financial, institutional, and socio-cultural remain underexplored, warranting context-driven research like the present study.

3. Research Methodology

3.1 Research Design

This study adopts a case study design to provide an in-depth analysis of SMEs in Lusaka Business Centre integrating renewable energy. Case studies enable exploration of complex social phenomena where context and subject overlap (Yin, 2018). The approach supports mixed methods, combining qualitative insights and quantitative trends to capture diverse technologies, business outcomes, and institutional limitations. Lusaka Business Centre serves as a bounded case, allowing focused examination of SME responses to energy transition pressures. This design facilitates understanding both subjective experiences and measurable operational outcomes (Hyett, Kenny & Dickson-Swift, 2014).

3.2 Target Population

The target population comprises SME owners, managers, renewable energy technicians, and policy actors in Lusaka Business Centre. These participants are directly involved in energy use, business operations, and regulatory processes, providing firsthand insight into opportunities and constraints of renewable energy adoption. Focusing on SMEs in a dense urban center allows examination of energy use impacts on growth and productivity. Chanda and Chitundu (2021) highlight that SMEs in Lusaka are early adopters of renewable technologies due to unreliable grid supply and rising operational costs, making this population suitable for context-specific research.

3.3 Sampling Design and Sample Size

Purposive sampling was used to select 50 information-rich participants with direct experience in renewable energy adoption (Etikan, Musa & Alkassim, 2016; Fusch & Ness,

2015). This included 45 SME owners/managers, 3 renewable energy providers, and 2 policy actors, chosen based on business size (≤ 100 employees), location (Lusaka Business Centre), and prior engagement with solar PV, biogas, or hybrid systems. This non-probability approach prioritizes analytical depth, enabling triangulation of perspectives, capturing operational impacts, energy savings, revenue changes, and providing nuanced understanding of barriers and benefits in urban SME energy transitions.

3.4 Data Collection Methods

Data will be collected through semi-structured interviews and questionnaires. Interviews with SME owners, providers, and policy actors will explore technology types, operational and financial impacts, and adoption barriers. Questionnaires will capture energy cost reductions, revenue changes, operational hours, and adoption rates, with open-ended items providing qualitative insight. This multi-method approach enables triangulation, combining objective data with subjective experiences to produce reliable, context-specific evidence on renewable energy integration in SMEs (Turner, 2010).

3.5 Data Analysis

Data analysis integrates descriptive statistics and thematic analysis. Quantitative data will be summarized using frequencies, percentages, means, and cross-tabulations to identify adoption patterns, energy savings, and operational improvements (SPSS 27). Qualitative interview and open-ended responses will be coded thematically to identify adoption drivers, impacts, and constraints. Triangulating quantitative and qualitative findings ensures reliability and validity. This approach provides measurable evidence of renewable energy effectiveness while contextualizing institutional and operational factors shaping SME energy transitions in Lusaka Business Centre (Vaismoradi *et al.*, 2016) [23].

4. Findings and Results

4.1 Background Characteristics of Respondents

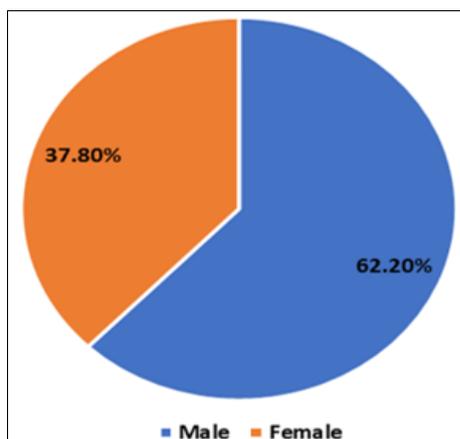


Fig 1: Distribution of Respondents by Gender

Males dominated with 62.2% compared to 37.8% female. This suggests that decision making and investment in business energy systems may still be heavily influenced by male led enterprises.

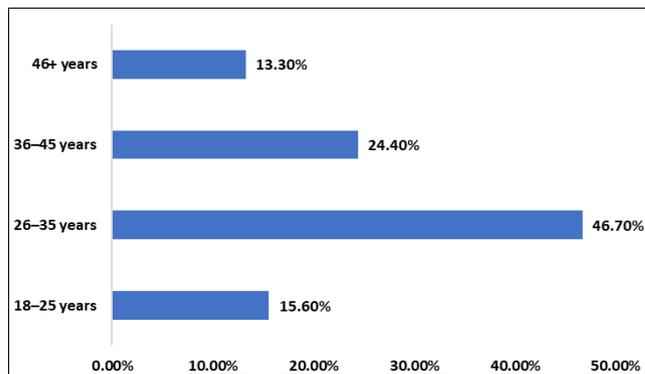


Fig 2: Age Groups

The majority of SMEs adopting renewable energy are youthful: 21 respondents (46.7%) aged 26–35 and 11 (24.4%) aged 36–45. Younger entrepreneurs are more receptive to innovation, driving higher adoption of renewable technologies in Lusaka Business Centre businesses.

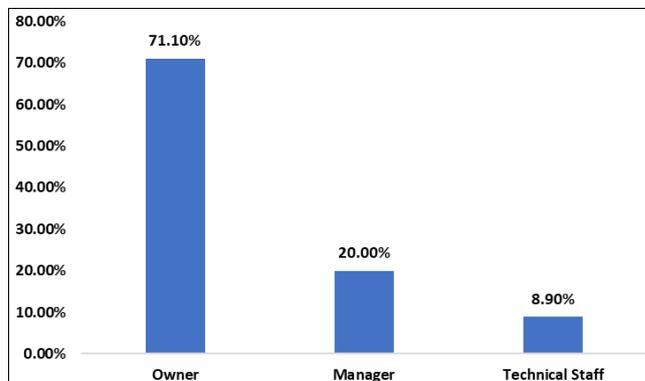


Fig 3: Distribution of Respondents by Business Position

Most respondents were business owners accounting for 32 (71.1%) followed by managers at 9 (20.0%). A small proportion of responses were obtained from technical staff 4 (8.9%). This distribution demonstrates that adoption decisions are predominantly driven by those holding strategic leadership roles with direct responsibility for financial and operational sustainability.

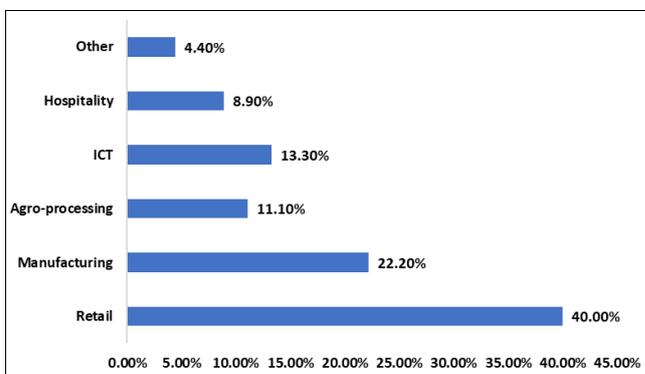


Fig 4: Distribution of Respondents by Business Sector

(40.0%). Manufacturing follows at 10 (22.2%) while ICT and agro processing account for 6 (13.3%) and 5 (11.1%) respectively. This distribution reflects the composition of

SMEs within the central business area of Lusaka and suggests that renewable energy adoption spans diverse sectors particularly those dependent on continuous power to support refrigeration, digital services, and light manufacturing.

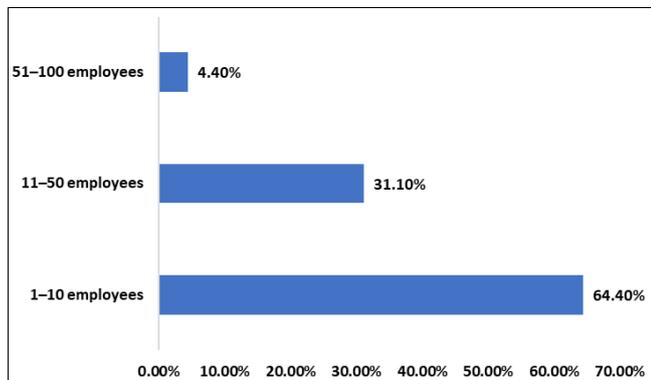


Fig 5: Distribution of Respondents by Number of Employees

The results indicate that most participating SMEs fall within the micro and small enterprise category with 29 (64.4%) employing between one and ten workers. Only 2 (4.4%) have staffing levels above fifty. The dominance of small-sized enterprises implies limited financial capacity which may influence both the type of renewable energy technologies adopted and the scale of resulting business improvements.

4.2 Types of Renewable Energy Technologies Adopted by SMEs

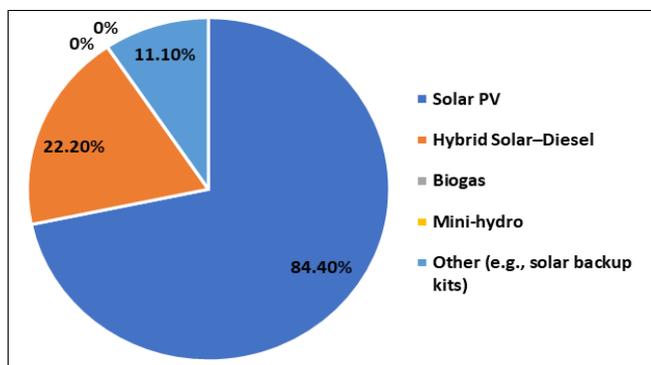


Fig 6: Types of Renewable Energy Technologies Adopted

Multiple responses were allowed. Solar Photovoltaic systems dominate adoption, used by 84.4% of SMEs due to affordability, availability, and efforts to offset Lusaka’s load shedding. Hybrid solar-diesel systems (22.2%) provide backup during low sunlight. No SMEs use biogas or mini-hydro, limited by cost, infrastructure, and space. Experts note SMEs prefer quick-install solar solutions for lighting,

computing, and sales. Biogas and hydro remain impractical in the commercial centre, making solar the most feasible option.

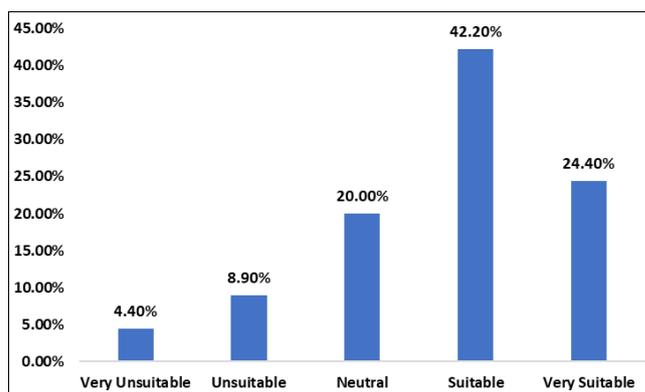


Fig 7: Suitability of Adopted Technology

Most SMEs find renewable energy systems adequate for operations, with 66.6% rating them suitable or highly suitable for lighting, refrigeration, machinery, and security. However, 13.3% view them as unsuitable for high-energy equipment like industrial freezers or ovens. About 20% expressed neutrality, reflecting inconsistent solar performance. Experts noted suitability improves with proper system sizing, emphasizing that many SMEs purchase affordable options rather than systems matched to their actual power needs.

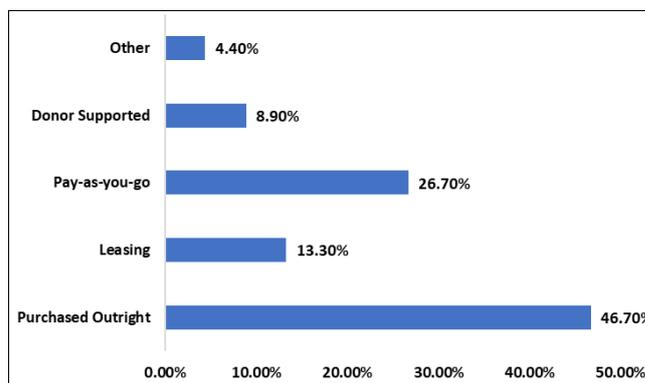


Fig 8: Acquisition Method

Nearly half of SMEs (46.7%) acquired renewable systems through direct purchase, showing investment readiness where capital allows. Pay-as-you-go models (26.7%) enable smaller firms to adopt solar affordably, while leasing (13.3%) is emerging. Limited donor support (8.9%) reflects minimal external funding in Lusaka’s commercial zones. Providers highlighted financing as the main barrier, noting that many SMEs seek larger systems but face restrictive credit and limited access to affordable loans.

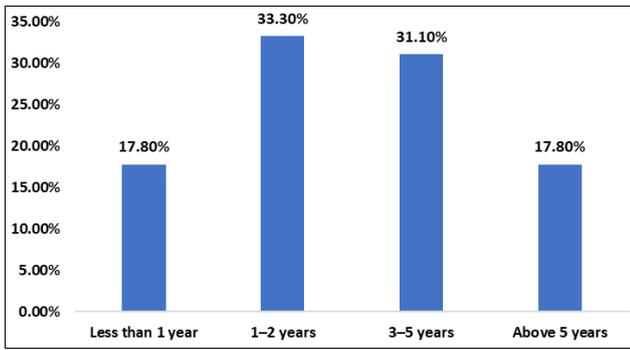


Fig 9: Duration of Use

About 64.4% of SMEs have used renewable technologies for one to five years, reflecting adoption during major load shedding periods. Only 17.8% report use beyond five years, representing early adopters. The high share of recent installations signals market growth and rising confidence in renewables. Providers noted a sharp uptake during the 2019–2023 electricity crises, when persistent outages pushed businesses to invest in reliable backup power.

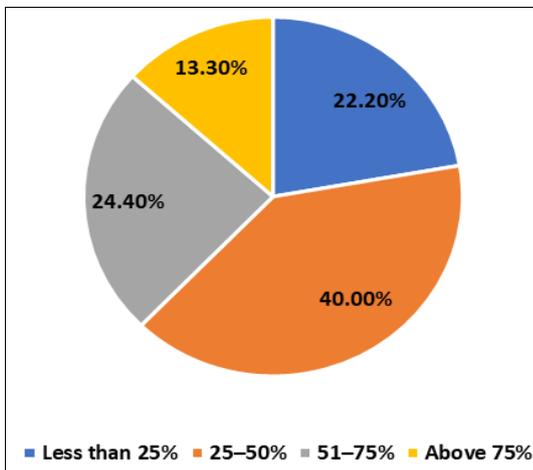


Fig 10: Proportion of Energy Requirements Met

Most SMEs reported renewable energy meeting 25–50% of their power needs (40.0%), showing effectiveness for basic operations but continued reliance on grid electricity for high-energy tasks. Only 13.3% achieved high grid independence, reflecting high costs and technical limits. Smaller service-based firms benefit more than manufacturers. Experts noted that greater battery storage could enhance independence, but high prices continue to restrict adoption among Lusaka’s SMEs.

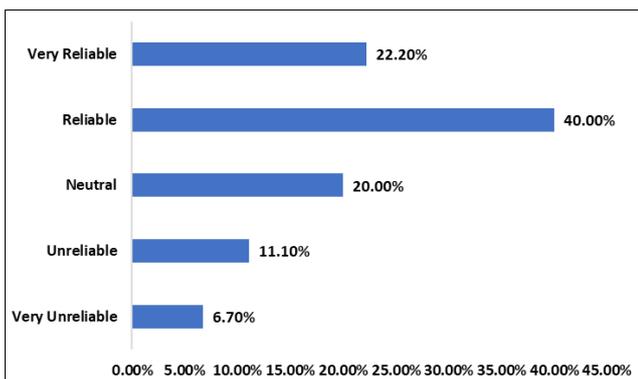


Fig 11: Reliability Compared to Grid Electricity

About 62.2% of SMEs rated renewable systems as reliable or very reliable, underscoring their importance during Lusaka’s frequent outages. Neutral responses (20.0%) reflect variable performance from weather or under-sized systems, while 17.8% found them unreliable, mainly in energy-intensive sectors. Providers emphasized that reliability depends on system quality and correct load sizing, noting that cheaper, poorly designed kits often cause power disruptions for small businesses.

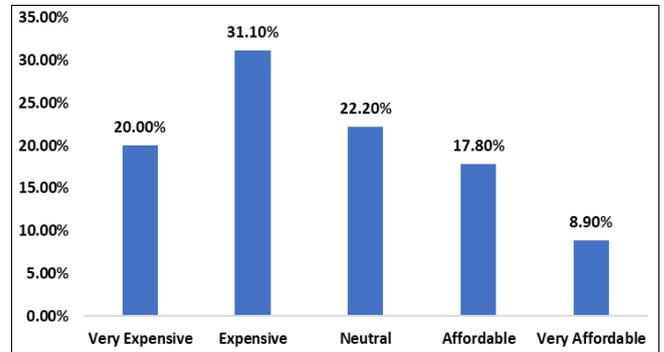


Fig 12: Affordability of Installation

Over half of SMEs (51.1%) rated renewable installations as expensive or very expensive, showing upfront cost remains a key adoption barrier. About 26.7% found them affordable, mostly small users of solar backup kits, while 22.2% were neutral, reflecting varied financial capacity. Overall, high costs hinder scaling among businesses needing larger systems. Experts stressed the lack of tailored SME financing, noting that affordable credit could rapidly boost adoption.

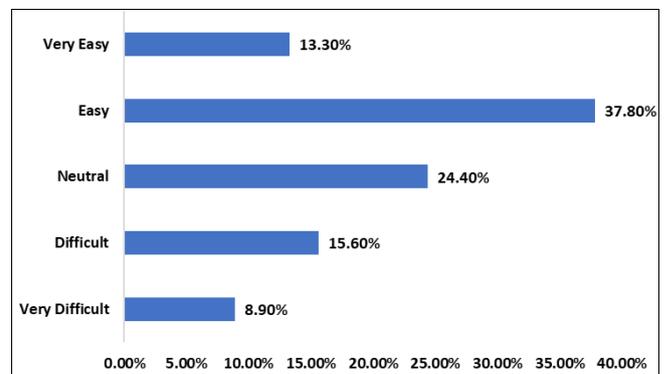


Fig 13: Ease of Maintenance

Most SMEs (51.1%) rated renewable systems as easy or very easy to maintain, reflecting accessible local technicians and user-friendly designs. About 24.5% reported difficulties with complex components like inverters and batteries, while 24.4% were neutral, often outsourcing maintenance. Providers noted that most issues stem from dust buildup and poor battery handling, emphasizing that proper care makes maintenance simple, whereas neglect leads to performance problems.

4.3 Effectiveness of Renewable Energy Technologies Adopted by SMEs

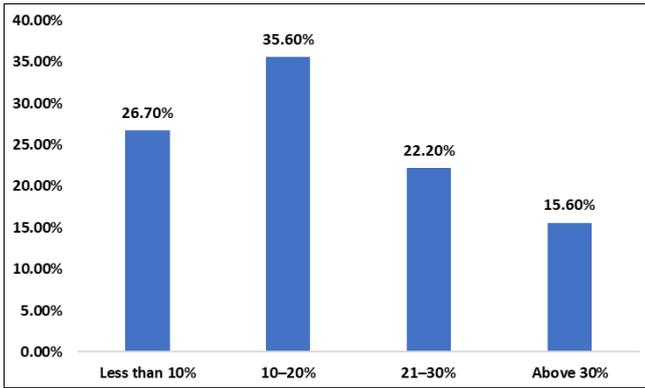


Fig 14: Reduction in Monthly Energy Costs

Most SMEs (35.6%) reported moderate energy cost reductions of 10–20%, showing renewables’ positive impact on operational expenses. About 22.2% achieved 21–30% savings, and 15.6% saved over 30%. Those with minimal savings (26.7%) used small systems powering few appliances. Overall, savings depend on system size and business type, with major benefits seen after scaling up capacity for high-energy operations, according to key informants.

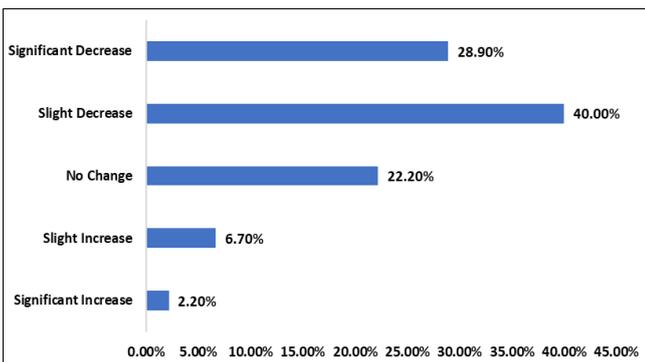


Fig 15: Effect on Operational Downtime

Renewable energy has reduced operational downtime for most SMEs, with 68.9% reporting fewer disruptions during load shedding, thanks to reliable solar backup for lighting, computers, refrigeration, and security. About 22.2% saw no change, as systems covered only non-critical functions, while 8.9% experienced increased downtime due to inverter issues or cloudy weather. Key informants noted that even small solar setups can maintain operations when grid power fails, preserving productivity and customers.

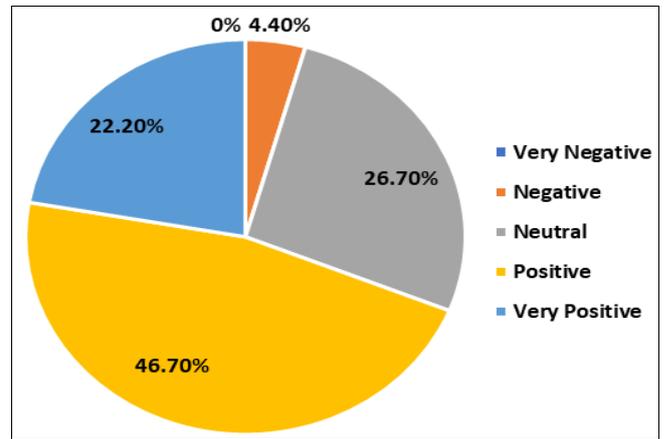


Fig 16: Comparison of Monthly Energy Costs Before and After CBRE Installation

Most SMEs reported revenue growth after adopting renewable energy, with 46.7% noting improved sales and 22.2% very positive effects. Enhanced power reliability extended operating hours and reduced interruptions, boosting customer retention. About 26.7% saw no change, mainly in low-energy businesses, while 4.4% experienced negative effects from maintenance or undersized systems. Interviews confirmed that revenue gains depend on system capacity and alignment with core business functions.

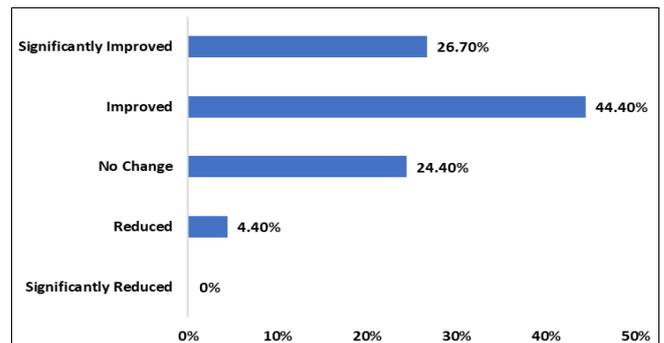


Fig 17: Effect on Staff Productivity

Renewable energy adoption has boosted staff productivity, with 71.1% reporting improved performance due to uninterrupted electricity, efficient task completion, and reduced idle time during outages. Only 4.4% experienced declines from system faults, while 25% saw no change, mostly in low-energy businesses. Experts noted the greatest gains occur in ICT, retail, and hospitality, where lighting and digital systems are critical. A key informant emphasized that solar ensures a consistently powered, productive workplace.

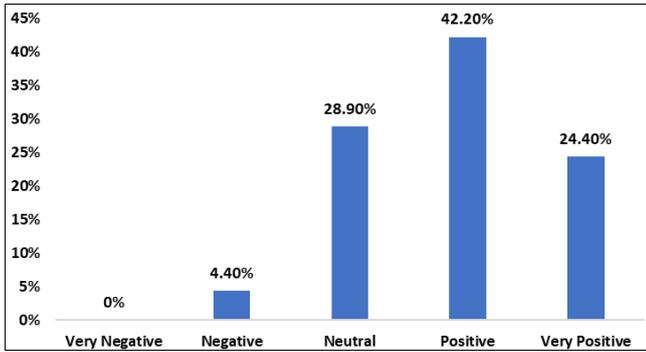


Fig 18: Customer Service Performance

About 66.6% of SMEs reported positive impacts of renewable energy on customer service, with reliable lighting, uninterrupted transactions, and functional refrigeration improving speed and quality. ICT and hospitality businesses particularly benefited from stable internet and digital tools. Neutral responses (28.9%) occurred in mainly manual operations, while 4.4% faced negative effects from underperforming systems. A key informant noted that solar ensures efficiency, keeping customers satisfied and reducing losses from power outages.

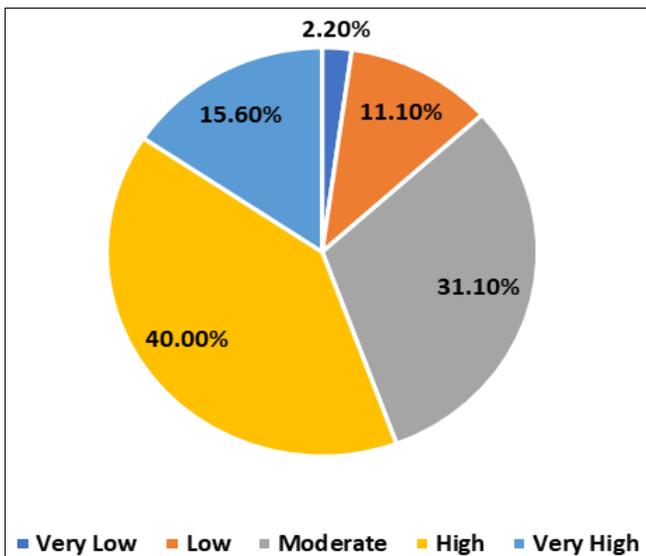


Fig 19: Overall Contribution to Business Growth

Overall, 55.6% of SMEs reported high contributions of renewable energy to business growth, viewing it as a strategic tool for continuity and competitiveness. About 31.1% noted moderate impact, while 13.3% rated it low due to technical limits or underused systems. Qualitative insights show that integrating renewables into core production and customer services yields tangible growth. An interviewee

noted that early adopters gain a clear advantage in Lusaka’s business centre.

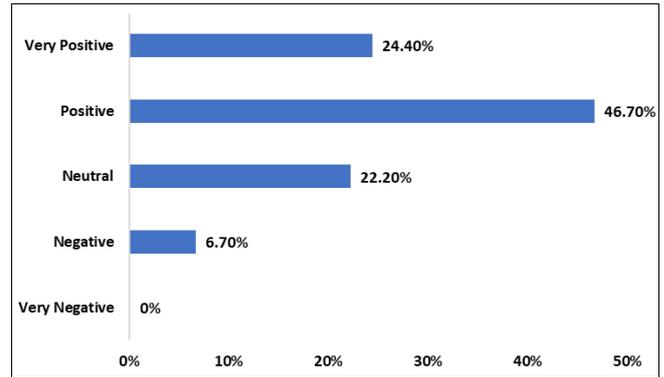


Fig 20: Influence on Business Competitiveness

Most SMEs (71.1%) reported enhanced competitiveness from renewable energy, citing reduced downtime, better customer service, and extended hours, giving them an edge over non-adopters. Neutral responses (22.2%) were mainly small retailers in saturated markets, while 6.7% experienced negative effects from system faults. Experts emphasized that businesses operational during load shedding attract customers from competitors reliant on the grid, with one noting: “The business that has power when others do not automatically dominates the market.”

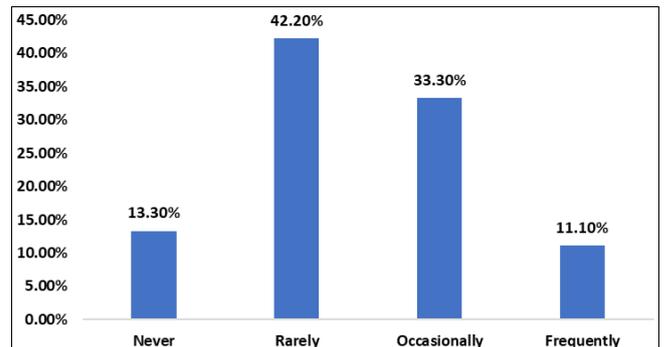


Fig 21: Frequency of Technical Issues Affecting Performance

Most SMEs (55.5%) rarely experience technical issues with renewable systems, reflecting improved quality and local support. However, 33.3% reported occasional faults, and 11.1% faced frequent breakdowns, often with low-cost systems lacking batteries or warranties. Experts noted that environmental factors like dust, poor ventilation, and improper wiring contribute to problems. A provider emphasized that properly engineered systems with correct load assessments minimize technical challenges and ensure reliable operation.

4.4 Limitations Associated with Renewable Energy Integration

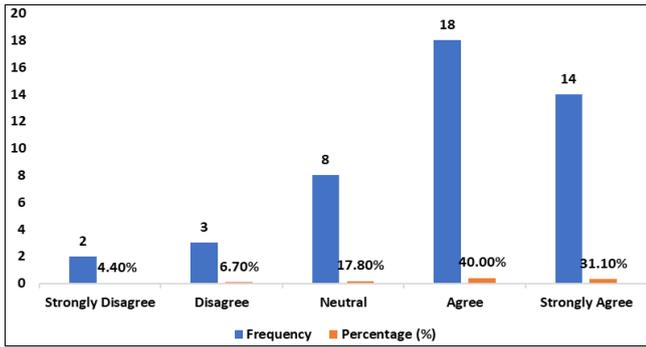


Fig 22: High initial cost is a challenge

A strong majority (71.1%) of SMEs view initial cost as a major barrier, with 40.0% agreeing and 31.1% strongly agreeing. Only 11.1% disagreed, while 17.8% were neutral. This confirms that upfront investment is the main deterrent to scaling renewable systems in Lusaka. KII in interviews noted limited access to low-interest loans and that pay-as-you-go schemes often fail to cover commercial battery and inverter costs, reinforcing financial constraints for SMEs.

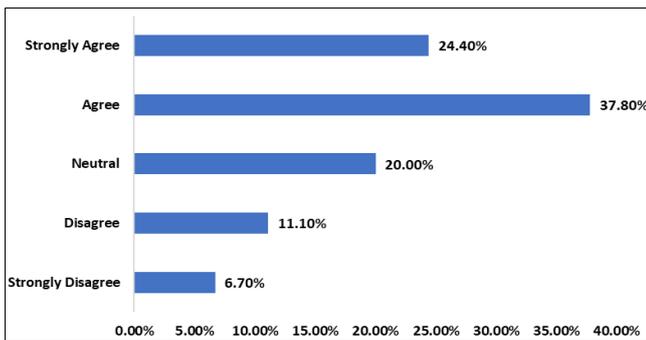


Fig 23: Lack of technical expertise limits effective use

A total of 52.2% of SMEs reported that limited technical expertise hinders effective renewable energy use (37.8% agree, 24.4% strongly agree), while 17.8% disagreed and 20.0% were neutral. This reflects differences between professionally installed systems and those from informal vendors. KIIs noted that many small installers lack certification and provide inconsistent after-sales training. A provider emphasized: “SMEs need basic training for battery care and load management; without it, system uptime falls.”

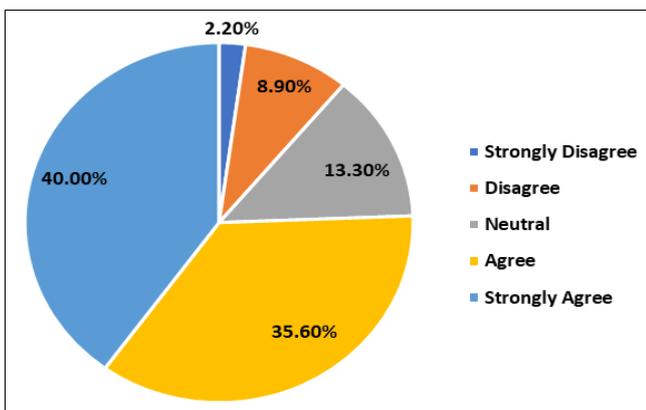


Fig 24: Access to finance is difficult

Access to finance is a major constraint, with 75.6% of SMEs agreeing (35.6% agree, 40.0% strongly agree) and only 11.1% disagreeing; 13.3% were neutral. This reinforces that high upfront costs limit adoption, as many SMEs lack tailored credit or working capital for renewables. KIIs noted banks’ limited interest in small commercial loans and restrictive collateral requirements, with interviewees recommending government-backed or blended financing to close the gap and support scaling.

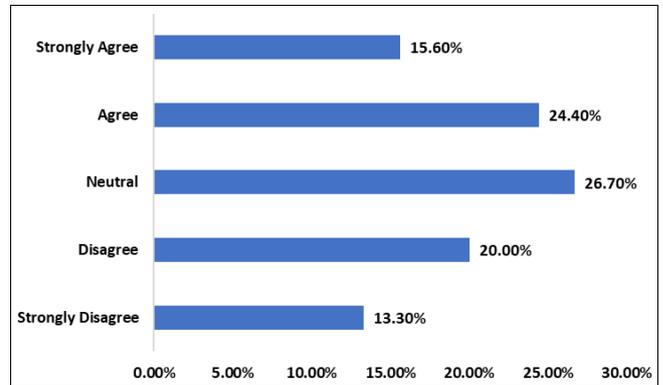


Fig 25: Regulatory barriers hinder adoption

Perceptions of regulatory barriers were mixed: 40.0% of SMEs felt regulations hinder adoption (24.4% agree, 15.6% strongly agree), 33.3% disagreed, and 26.7% were neutral. KIIs highlighted that, despite a national solar policy, SME-friendly incentives are limited. Challenges include bureaucratic delays for grid interconnections, lack of tax breaks for commercial batteries and inverters, and unclear installation standards, making regulation a moderate but important constraint, especially for larger or grid-connected systems.

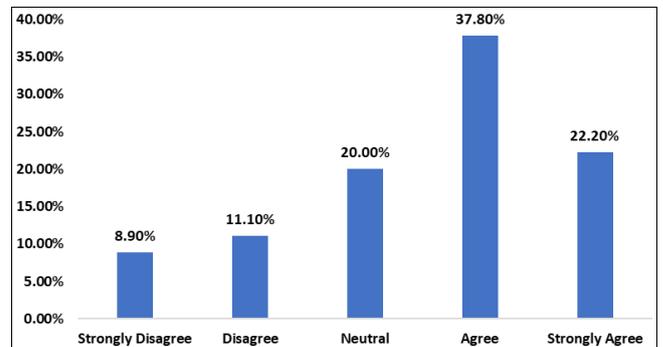


Fig 26: Limited availability of spare parts or suppliers

Availability of spare parts is a major operational challenge, with 60.0% of SMEs agreeing (37.8% agree, 22.2% strongly agree), 20.0% neutral, and 20.0% disagreeing. KIIs noted that many components are imported, causing delays and higher costs due to currency fluctuations and customs. SMEs using standard modern equipment faced fewer issues, while those with older or custom systems experienced long lead times, aligning with earlier findings on replacement costs and technical problems.

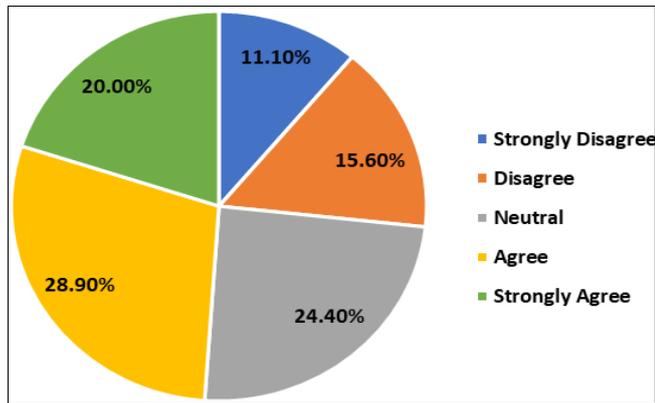


Fig 27: Inadequate training of staff

Inadequate staff training was identified as a challenge by 48.9% of SMEs (28.9% agree, 20.0% strongly agree), while 26.7% disagreed and 24.4% were neutral. Gaps are especially evident in battery care, basic troubleshooting, and electrical safety. KIIs noted that training is often included only in premium installations; otherwise, SMEs rely on technicians or online guidance. Findings highlight the need for targeted capacity building to prevent technical failures and prolong system lifespan.

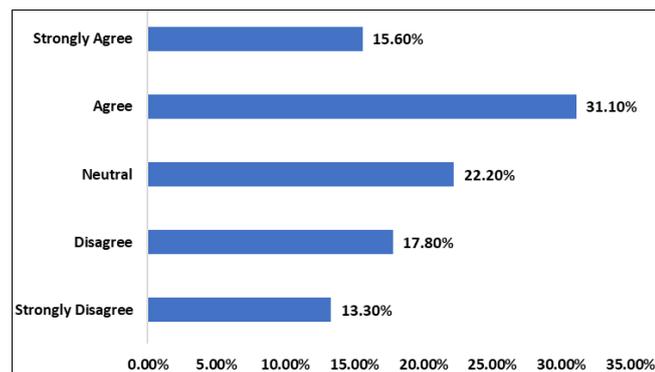


Fig 28: Technology incompatibility with existing equipment

Nearly half of SMEs (46.7%) view technology incompatibility as a barrier (31.1% agree, 15.6% strongly agree), while 31.1% disagreed and 22.2% were neutral. Issues include mismatched inverters, undersized solar arrays, and inability to support heavy equipment like industrial freezers. KIIs emphasized that proper load assessments and professional pre-installation audits are critical to avoid undersized systems and ensure reliable performance.

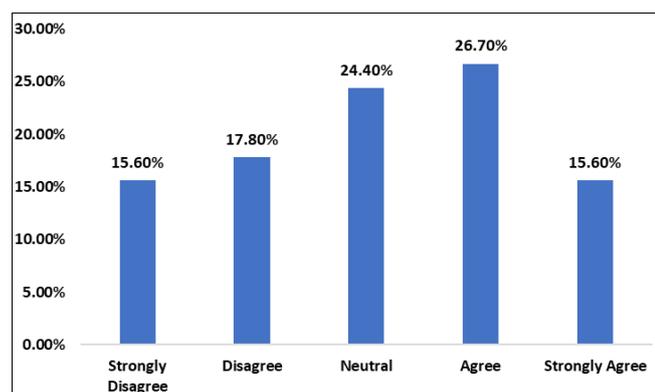


Fig 29: Policy incentives are insufficient

A total of 42.3% of SMEs (26.7% agree, 15.6% strongly agree) reported that policy incentives are insufficient, while 33.4% disagreed and 24.4% were neutral. KIIs highlighted limited tax relief, import duty exemptions for commercial batteries and inverters, and scarce grants or rebates, reducing the appeal of growth-oriented renewable systems. Findings suggest that incentives are more critical for scaling and system replacement than for small modular purchases.

4.6 Discussion of Results

Thematic Area 1: Types of Renewable Energy Technologies Adopted by SMEs

Renewable energy adoption among SMEs in Lusaka Business Centre is driven primarily by the need for reliable power rather than environmental concerns. Solar photovoltaic systems dominate (84.4%), reflecting responses to load shedding, grid instability, and high tariffs, while biogas and mini-hydro remain absent due to space, infrastructure, and feedstock constraints. Most SMEs (66.6%) find systems suitable for core operations like lighting, refrigeration, and point-of-sale equipment, though 13.3% report mismatches from undersized or low-quality installations. Financial constraints influence adoption: 46.7% purchase directly, 26.7% use pay-as-you-go models, and donor support is minimal (8.9%). Adoption timelines align with Zambia’s 2019–2023 power crises, emphasizing operational continuity over sustainability. Systems partially meet energy needs, with 62.2% covering up to half of demand, and 62.2% rate them reliable. While 51.1% find installation costly, maintenance is generally easy. Overall, SMEs strategically adopt renewables to reduce downtime, stabilize costs, and sustain revenue, though limited financing, undersized systems, and partial grid dependence indicate adoption remains transitional and requires stronger institutional support.

Thematic Area 2: The Effectiveness of Renewable Energy Technologies Adopted by SMEs

The study shows that renewable energy technologies have positively influenced operational efficiency, revenue, productivity, and business continuity among SMEs in Lusaka Business Centre. Most SMEs reported electricity cost reductions of 10–20%, reflecting small-scale system use for lighting and basic appliances rather than full production needs. Operational downtime decreased for 68.9% of SMEs, enabling extended service hours and reduced losses during load shedding. Revenue growth and customer retention improved for 68.9%, while 71.1% noted higher staff productivity. Enhanced customer service and competitiveness were reported by 66.6% and 71.1% of SMEs, respectively, demonstrating reputational and market advantages. Technical challenges affected 44.4% of SMEs, mainly due to low-cost or undersized systems and limited technical skills. Overall, renewable energy technologies contribute significantly to business resilience and competitiveness, though effectiveness depends on system size, sector, financing access, and maintenance support. Scaling, improved financing, and stronger technical capacity would further enhance outcomes.

Thematic Area 3: Limitations of Renewable Energy Integration in Supporting SME Growth

Renewable energy adoption among SMEs in Lusaka Business Centre is constrained by financial, technical, and institutional factors. Access to finance emerged as the primary barrier, with 75.6% reporting difficulty securing

funding, compounded by high upfront costs perceived as prohibitive by 71.1%. Limited spare parts and supplier availability (60%) highlight fragility in the local supply chain, prolonging downtime and deterring investment. Technical challenges, including lack of expertise (52.2%), inadequate staff training (48.9%), and technology incompatibility (46.7%), further undermine system performance. Institutional factors also play a role: 40% of SMEs viewed regulatory barriers as restrictive, and 42.3% found policy incentives insufficient. These combined constraints demonstrate that adoption success depends on financing, technical support, supply reliability, and policy frameworks. While SMEs recognize renewables' reliability and cost benefits, ecosystem gaps limit sustainability. Strengthening financing, capacity-building, and institutional support is critical to transforming renewable energy from a coping mechanism into a strategic growth enabler for Lusaka SMEs.

5. Conclusion

The study assessed the effectiveness of renewable energy integration on business growth among SMEs in Lusaka Business Centre. Solar photovoltaic systems were the most widely adopted due to affordability, availability, and suitability for urban commercial settings. SMEs primarily use renewables for essential functions lighting, refrigeration, computers, and security reducing vulnerability to unstable grid electricity. Financing options, including direct purchase and pay-as-you-go, have enhanced accessibility, though high upfront costs remain a major barrier. Adoption has led to notable improvements in business performance. Many SMEs reported reduced energy costs, enhanced operational efficiency, and decreased downtime during load shedding. Reliable power increased staff productivity, improved customer service, supported revenue growth, and strengthened competitiveness by enabling extended operating hours, consistent product quality, and uninterrupted service. However, challenges persist. Partial energy coverage, high installation and upgrade costs, limited technical expertise, and occasional equipment malfunctions restrict full benefits. The absence of tailored financing and inconsistent after-sales support further constrain high-capacity system adoption, while limited storage capacity leaves operations vulnerable during prolonged cloudy periods. In conclusion, renewable energy is an effective strategic solution for SME growth in Lusaka. Strengthening policy support, financing mechanisms, and technical capacity can help SMEs scale systems, enhance resilience, and achieve sustainable economic growth.

5.1 Recommendations

The study recommends that to enhance renewable energy adoption among SMEs in Lusaka, the government should introduce targeted financing schemes, including low-interest loans and tax incentives, while banks and microfinance institutions expand pay-as-you-go and leasing options to reduce upfront costs. Providers must improve system sizing and after-sales support, and SMEs should invest in scalable systems aligned with business growth. Capacity-building programs are needed to train staff on maintenance and energy management, complemented by awareness campaigns highlighting financial and operational benefits. The Ministry of Energy should enforce quality standards to reduce system failures, and integration of battery storage

should be prioritized to ensure reliability. Finally, collaborative research and pilot projects should explore innovative solutions suitable for urban commercial environments, fostering sustainable, efficient, and resilient renewable energy adoption.

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