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## **Effects of Prolonged Power Outages on Production Efficiency and Profitability of Manufacturing Small and Medium-Sized Enterprises (SMEs) in Lusaka District**

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### **Abstract**

This study examined the effects of prolonged power outages on the production efficiency and profitability of manufacturing SMEs in Lusaka District. It specifically assessed the extent of production disruptions, the impact on operational costs, coping strategies employed, and recommendations to enhance energy reliability and resilience. Using a descriptive and correlational design, data were collected from 100 SMEs and analyzed with SPSS and Excel. Results showed that power outages were frequent, with 28% of SMEs experiencing very frequent interruptions and 36% frequent outages. Correlation analysis revealed

strong positive relationships between outage frequency and production disruptions, including idle machinery ( $r = 0.703$ ,  $p < 0.01$ ) and delayed orders ( $r = 0.655$ ,  $p < 0.01$ ). Outages significantly increased operational costs, with additional expenses ranging from K5,001 to over K50,000. SMEs relied on coping strategies such as generators or alternative power sources (42%), rescheduling production (25%), and outsourcing (12%). Recommended measures included investment in renewable energy, installation of backup generators, energy-efficient production methods, strategic stockpiling, and operational rescheduling.

**Keywords:** Prolonged Power Outages, Production Efficiency, Profitability, Manufacturing SMEs, Coping Strategies, Energy Reliability, Business Resilience

### **1. Introduction**

Energy plays a central role in the economic and social development of any country. A stable and reliable electricity supply is critical to industrialization, poverty reduction, and the overall competitiveness of enterprises. Globally, countries that have achieved sustained economic growth and industrial advancement have consistently invested in energy security to power industries, support innovation, and sustain value chains (World Bank, 2023) <sup>[54]</sup>. In developed nations, reliable electricity access is often taken for granted, but in developing countries such as Zambia, access to uninterrupted energy remains a significant challenge that undermines economic activity.

Small and Medium-Sized Enterprises (SMEs) constitute the backbone of most economies, contributing substantially to job creation, poverty reduction, and gross domestic product (GDP). In Zambia, SMEs account for more than 70 percent of employment opportunities and nearly 30 percent of GDP (Zambia Development Agency, 2022) <sup>[57]</sup>. Within the SME landscape, the manufacturing sector plays a particularly strategic role as it not only provides employment but also drives value addition, supports industrialization, and reduces dependence on imports. The manufacturing sector in Lusaka District includes diverse activities such as food processing, beverage production, metal fabrication, wood processing, textiles, and small-scale chemical production. All these activities depend heavily on reliable power supply for machinery, equipment, refrigeration, and production lines.

However, Zambia has faced persistent challenges in providing stable electricity to meet growing demand. The national grid is highly dependent on hydropower, which contributes over 80 percent of electricity generation. This dependence has exposed the country to significant risks due to climate variability, especially droughts that reduce water levels in reservoirs such as Kariba Dam. The 2015–2016 drought, for example, led to severe load shedding across the country, with outages lasting up to 12 hours per day in urban areas, including Lusaka. More recently, the 2019–2020 drought and the 2022 dry spells once again disrupted power supply, highlighting the vulnerability of Zambia's energy sector to climate shocks.

For SMEs in Lusaka, prolonged power outages have direct and indirect effects. Directly, they cause production stoppages, reduce machine utilization, and lead to wastage of raw materials. For instance, in food processing SMEs, prolonged outages result in spoilage of perishable goods such as dairy products, meat, and baked goods. In metal works and fabrication, machines sit idle, leading to unfinished orders and delays in delivery. Indirectly, outages increase operational costs as SMEs are forced to invest in alternative sources of energy such as diesel generators, inverters, and solar systems. While these alternatives ensure minimal continuity, they significantly increase production costs and erode profit margins.

Load shedding, a term commonly used in Zambia to describe scheduled power outages, has become a significant challenge affecting socio-economic activities across the country. Globally, electricity is a critical resource for economic growth and development. In industrialized countries, power outages are typically rare and often occur due to natural disasters or technical failures. These outages, however, tend to be brief, as advanced infrastructure allows for quick restoration of electricity (Larsen *et al.*, 2015) [34]. In developing nations, the situation is far different, with frequent and prolonged power outages disrupting economic activities, especially for small and medium-sized enterprises (SMEs). The reliance on unstable power grids in these countries hampers productivity and increases operational costs for businesses, which are forced to rely on alternative and often expensive energy sources.

Several Sub-Saharan Africa (SSA) countries, Zambia inclusive, have experienced power shortages, with the regional shortage estimated at 8,247 MW (Kaseke, 2013) [29]. This has, in most instances, triggered load shedding. Since early 2015, Zambia experienced a 2,100 gigawatt-hours (GWh) power shortage triggering countrywide load shedding. For example, in Pakistan, load shedding caused a 1.8% (translating to Rs 9.3 billion) loss of the gross domestic product (GDP) between 1975 and 1976 (Kessides, 2013) [32]. In India, losses from load shedding amounted to US\$2.7 billion for the period 1983/1984, representing 1.5% of the GDP, while US\$2.1 billion was lost in 1982/83, representing 2.1% of the GDP (Sangvhi, 1991) [44]. In Zimbabwe, load shedding caused GDP losses of up to 32% for each kilowatt-hour (kWh) lost (Kaseke, 2013) [29].

Small and medium-sized enterprises (SMEs) are vital to Zambia's economy, contributing significantly to employment creation, innovation, and poverty reduction (Phiri & Chisanga, 2020) [41]. In Lusaka District, SMEs form the backbone of the informal and formal business sectors. However, persistent power supply interruptions have emerged as a major constraint to their operational sustainability. Zambia's energy sector has been under increasing strain due to overreliance on hydropower, which is highly susceptible to drought and seasonal water fluctuations (Energy Regulation Board [ERB], 2023) [15]. In early 2024, Lusaka District experienced a sharp escalation in load-shedding due to low water levels in the Kariba Dam and increased power demand (ZESCO, 2024; Zambia Daily Mail, 2024) [60, 56]. Based on ZESCO's load-shedding schedule and verified reports, the following trend of power outages was observed:

**Table 1:** Trend of Power Outages in Lusaka District from January to April 2024

Month	Average Daily Outage (hours)	Frequency (Days/Month)	Total Monthly Downtime (hours)
January 2024	6 hours	22 days	132 hours
February 2024	8 hours	25 days	200 hours
March 2024	10 hours	27 days	270 hours
April 2024	12 hours	29 days	348 hours

**Source:** Data compiled from ZESCO (2024) [60] load-shedding schedule and Zambia Daily Mail (2024) [56] news report on prolonged power outages

This upward trend in power outages has severely affected SMEs' operations, especially those in manufacturing, service provision, and technology-based sectors. Many businesses have resorted to costly alternatives such as fuel-powered generators, which significantly increase operational expenses and reduce profit margins (Kalinda, 2021) [25]. The background therefore underscored the importance of this study. While policy discussions often highlighted power shortages in Zambia, there was limited empirical data specifically focusing on how prolonged outages affected the production efficiency and profitability of SMEs in the manufacturing sector.

### 1.1 Statement of the Problem

Small and Medium-Sized Enterprises (SMEs) are essential to Zambia's economy, accounting for approximately 97% of all businesses, contributing around 70% of GDP, and employing about 88% of the workforce (Mubanga, 2022). Despite this importance, SMEs, especially those in the manufacturing sector, are under increasing threat from recurrent and prolonged power outages. In Lusaka, load shedding has become routine. ZESCO has at times imposed between 10 to 12 hours of daily outages on a rotational basis across many areas (Lusaka Times, 2020), and in 2024 introduced a staggered load shedding schedule where residential areas had two 4-hour outages per day, while industrial areas faced an 8-hour continuous block (Lusaka Times, 2024; Diggers News, 2024). These disruptions have tangible business effects:

- Manufacturing firms report sharply increased production costs, particularly for fuel to run generators, maintenance, and equipment wear (Zambia Association of Manufacturers, 2023).
- The decline in electricity generation to about 18,972.82 GWh in 2023, a drop from the previous year, has worsened supply instability (Financial Insight, 2023).

These combinations of factors lead to machine downtime, delays in order fulfilment, spoilage of raw materials, and erosion of profit margins. However, the magnitude of these effects among manufacturing SMEs in Lusaka District in terms of production efficiency loss and reduced profitability has not been empirically measured.

### 1.2 Purpose of the Study

The purpose of this study was to investigate the effects of prolonged power outages on production efficiency and profitability of manufacturing SMEs in Lusaka District, with the aim of providing recommendations that enhance business resilience and sustainability.

### 1.3 Objectives of the Study

1. To assess the extent to which prolonged power outages disrupt production processes of manufacturing SMEs in Lusaka District.
2. To evaluate the effect of power outages on the operational costs and profitability of manufacturing SMEs.
3. To investigate the coping strategies adopted by manufacturing SMEs to mitigate the effects of power outages.
4. To provide recommendations for improving energy reliability and resilience of SMEs in the manufacturing sector.

### 1.4 Conceptual Framework

The conceptual framework illustrated the relationship between prolonged power outages and SME performance in the manufacturing sector in Lusaka District. Prolonged power outages were conceptualized as extended and frequent electricity interruptions that disrupted normal operations, leading to reduced productivity, production delays, equipment damage, and increased operational costs. These direct effects demonstrated how unreliable electricity supply constrained the operational efficiency and financial stability of SMEs, making energy reliability a critical factor influencing business performance outcomes.

Mediating factors were positioned between power outages and SME performance to show how firms responded to and absorbed disruptions. These included access to alternative energy sources, government policies and support mechanisms, and managerial resilience strategies such as production rescheduling and financial planning. SME performance was reflected through productivity, profitability, and employment capacity, with the framework assuming that the severity of negative outcomes depended on the strength of mediating factors. Drawing from the Resource-Based View and Contingency Theory, the framework emphasized that firms with stronger internal resources and adaptive capabilities, supported by favorable external policies, demonstrated greater resilience under conditions of energy instability.

### 1.5 Significance of the Study

This study carried significance at multiple levels, including policy, business, academic, and socio-economic domains. At the policy level, the findings provided empirical evidence to inform decision-makers by highlighting production losses and financial implications of power outages, offering guidance for targeted interventions consistent with national development goals. From a business perspective, the study illuminated the operational and financial costs associated with prolonged power outages and documented coping strategies that provided practical insights into resilience measures to sustain productivity and business continuity. Academically, the study contributed to the limited body of literature on energy reliability and SME performance by addressing sector-specific effects and providing a framework for future research on enterprise resilience and adaptive strategies. Socio-economically, the study underscored the importance of SMEs in economic development through employment creation, income generation, and value chain strengthening, while highlighting how improving SME resilience could support poverty reduction and inclusive growth.

## 2. Literature Review

### 2.1 Empirical studies

Reliable electricity is strongly correlated with firm productivity and competitiveness across contexts. The World Bank (2020) <sup>[52]</sup> estimates that firms in developing countries lose on average about 7% of annual sales due to power interruptions; this figure rises in particularly electricity-constrained economies. Studies in South and Southeast Asia indicate sizable productivity and revenue losses for manufacturing SMEs. Singh and Kathuria (2019) <sup>[45]</sup>, examining small and medium manufacturing firms in India, report an average weekly loss of about 10 hours of productive time due to outages, translating to an observable reduction in output and sales. Haque (2020) <sup>[18]</sup> found that in Pakistan outages increased production costs by as much as 25% for small manufacturers who relied on diesel generators.

In developed economies, although outages are rarer, their economic cost can be large when they occur. The U.S. Department of Energy (2017) <sup>[48]</sup> estimated that the economic effect of electrical outages in the United States amounts to tens of billions per year, largely due to business interruption effects. The contrast between developed and developing country experiences highlights two critical dimensions: (1) frequency/duration of outages (much higher in many developing contexts) and (2) the capacity to cope (greater in better-capitalized firms and countries).

The global literature also highlights common coping responses by SMEs: investment in backup generators (diesel), adoption of solar photovoltaic systems (where capital allows), use of uninterruptible power supplies (UPS) for sensitive equipment, and operational adjustments such as shift rescheduling or temporary closure during outages (Jensen & Lester, 2018; U.S. Department of Energy, 2017) <sup>[23, 48]</sup>. Cost-benefit analyses in several countries show that the decision to invest in backup capacity depends on outage frequency, fuel prices, capital costs, and expected revenue losses.

Prolonged power outages have emerged as a significant concern globally, effecting various socio-economic activities across different regions. In the United States, for example, a study by Caves, Frankel, and Golove (2013) <sup>[9]</sup> highlighted the economic implications of power outages, revealing that businesses faced losses averaging \$150,000 per hour during extended outages. This substantial financial effect underscores how energy reliability is critical for operational continuity, especially in sectors that are highly dependent on constant electricity supply. Similarly, in India, a research study by Khandker, Bakht, and Koolwal (2009) <sup>[33]</sup> found that frequent power outages negatively affected small enterprises, leading to reduced productivity and increased operational costs. The authors estimated that each power interruption cost small businesses up to 8% of their monthly revenue, illustrating the heavy burden of unreliable electricity supply on the economic viability of SMEs.

Sub-Saharan Africa (SSA) exhibits some of the most severe productivity losses associated with energy insecurity. Eberhard *et al.* (2017) <sup>[14]</sup> and the World Bank (2019) <sup>[51]</sup> document that unreliable power remains a key constraint on private sector growth across SSA, reducing firm productivity and increasing operational costs. Case studies across the region reveal several recurrent patterns.

In Nigeria, a large literature shows that firms routinely depend on diesel generators; Adenikinju (2020) <sup>[2]</sup> reports

that many firms spend between 30% and 40% of operating expenditures on fuel for backup generation, markedly eroding profit margins. Similarly, studies in Ghana (Amponsah-Tawiah & Dartey-Baah, 2020) [8] identified production capacity declines up to 20% attributable to outages, with service and manufacturing firms disproportionately affected.

Kenya provides insight into how firms within a relatively more diverse energy mix still contend with outages; Kamau and Munyua (2021) [26] found that small manufacturers lost approximately 10–15% of annual revenues due to outages and that the poorest firms rarely invested in backup due to upfront capital constraints. South Africa's recent experience (post-2019) with systemic load shedding demonstrates that even middle-income countries face severe SME effects: Turok (2021) [47] reports that small enterprises face increased costs, interrupted supply chains, and reduced investor confidence during extended power disruptions.

According to the World Bank's article titled *Doing Business*, firms in low-income countries are affected by electricity supply interruptions on average 18 times in a typical month. Business managers interviewed for the *Doing Business* project in Malawi, which was done in various countries by the World Bank, estimated that losses due to electricity outages amount to an average of 3.2 % of annual sales and as much as 22.6 %. These resulting workflow interruptions and the combined damage of sensitive electrical equipment such as computers caused by voltage fluctuations can significantly curtail profits.

Nigeria has been grappling with power shortages that significantly effect its socio-economic landscape. A study conducted by Adenikinju (2019) [1] estimates that businesses lose approximately \$29 billion annually due to unreliable electricity supply, accounting for about 2% of Nigeria's GDP. The research highlights the vulnerability of SMEs, which often lack the resources to invest in alternative energy solutions. Consequently, power outages lead to decreased productivity and operational efficiency, ultimately resulting in increased unemployment rates. The author calls for urgent reforms in Nigeria's power sector to ensure a stable electricity supply and promote economic growth.

The World Bank and African Development Bank have highlighted the detrimental effects of unreliable electricity supply on economic development in Africa. According to a report by the World Bank (2021) [53], access to reliable electricity is a fundamental driver of economic growth, yet many African countries continue to face significant power supply challenges. The report emphasizes the need for investment in energy infrastructure to enhance productivity and economic stability across the continent. Additionally, the African Development Bank (2022) underscores the importance of energy access for SMEs, noting that reliable electricity is crucial for fostering innovation, enhancing competitiveness, and supporting job creation in the region.

Zambia's electricity sector is dominated by hydropower, accounting for roughly 80% of generation (ZESCO, 2022) [58]. This reliance exposes the grid to rainfall fluctuations and droughts; notable episodes in 2015–2016 and 2019–2020 precipitated extensive load shedding, with urban areas such as Lusaka experiencing planned and unplanned outages lasting many hours per day (Nkonde, 2021) [39]. Government reports and industry briefs (ZACCI, 2022; ZESCO, 2022) [55, 58] document the macroeconomic stress associated with these outages.

Firm-level effects in Zambia mirror regional patterns: surveys by ZACCI (2022) [55] indicated that SMEs in Lusaka reported sales declines in the range of 15–25% during severe outage periods; Mwanakatwe (2022) [36] focused on food processing SMEs and documented operational cost increases of up to 40% attributable to diesel consumption and spoilage. The Zambia Association of Manufacturers (ZAM) has publicly testified to increased production costs and maintenance needs resulting from frequent power fluctuations (Lusaka Times, 2023) [35].

More recently, several countries in Sub-Saharan Africa (SSA), Zambia inclusive, have experienced power shortages, with the regional shortage estimated at 8,247 MW (SADC 2015). This has in most instances triggered load shedding. Since early 2015, Zambia experienced a 2,100 gigawatt-hours (GWh) power shortage triggering countrywide load shedding (Samboko *et al.*, 2016) [43]. A number of studies have been conducted on the effects of load shedding (see Kaseke, 2022) [30] though they have largely focused on macro level aspects. For instance, in Pakistan load shedding caused a 1.8% (translating to Rs 9.3 billion) loss of the gross domestic product (GDP) between 1975 and 1976 (Kessides, 2013) [32]. In India, losses from load shedding amounted to US\$2.7 billion for the period 1983/1984; representing 1.5% of the GDP, while US\$2.1 billion was lost in 1982/83 representing 2.1% of the GDP (Sangvhi, 1991) [44]. In Zimbabwe, load shedding caused GDP losses of up to 32% for each kilowatt-hour (kWh) lost (Kaseke, 2011) [28]. These examples albeit having a macroeconomic focus demonstrate that load shedding has potentially large effects on poor urbanites of developing countries such as Zambia.

## 2.2 Research Gap

Previous studies provided valuable insights into the effects of power outages on businesses, but notable gaps persisted, particularly in the context of manufacturing SMEs in Lusaka District, as global studies focused on macro-level effects without investigating sector-specific outcomes in the Zambian manufacturing context. Regional research emphasized general business performance and revenue loss but did not provide detailed analyses of coping mechanisms employed by firms or quantify their effectiveness. Local studies documented increased operational costs and reduced profit margins but did not systematically link the frequency and timing of power outages to production efficiency and profitability, nor evaluate which coping strategies were most effective and sustainable for manufacturing SMEs. Previous studies therefore left gaps in sector-specific analysis, strategy evaluation, and empirical measurement of performance effects, which the current study sought to address by focusing exclusively on manufacturing SMEs in Lusaka District and providing empirical evidence connecting outage metrics with operational performance and profitability.

## 3. Research Methodology

### 3.1 Research design

This study adopted a descriptive and correlational research design with a quantitative approach to investigate the effects of prolonged power outages on the socio-economic activities of SMEs in Lusaka District. The design enabled the collection and statistical analysis of numerical data to identify patterns and relationships between power outages

and factors such as productivity, operational costs, and profitability.

### 3.2 Research Site

The research was conducted in Lusaka District, Zambia’s capital city and a major economic hub with a high concentration of small and medium-sized enterprises (SMEs). The district was selected because of its significant exposure to prolonged power outages (load shedding), which have disrupted business operations and affected productivity, operational costs, and profitability. The diverse socio-economic environment of Lusaka provided an appropriate context for examining the effects of unreliable power supply on manufacturing SMEs.

### 3.3 Population, Sample and Sampling Procedure

The target population comprised approximately 1,000 registered manufacturing SMEs operating in Lusaka District. A sample of 100 SMEs, representing 10% of the population, was selected to ensure adequate representation. A stratified random sampling technique was used to enhance representativeness by categorizing SMEs into relevant groups and randomly selecting participants within each category, ensuring that each enterprise had an equal chance of inclusion.

### 3.4 Research Instruments and Data Analysis

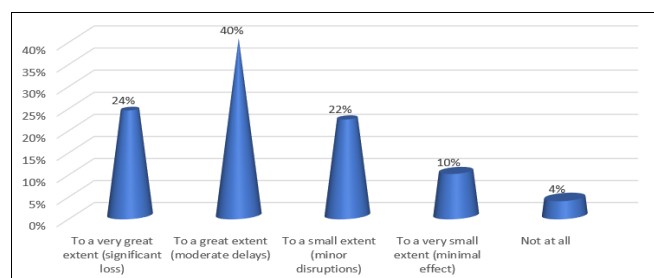
The study utilized a structured questionnaire consisting of closed-ended questions to collect quantitative data on the effects of prolonged power outages on SMEs. Collected data were first organized and cleaned using Microsoft Excel and later analyzed using SPSS. Both descriptive and inferential statistical methods, including correlations and t-tests, were applied to examine relationships between power outages and key variables such as productivity, operational costs, and profitability.

### 3.5 Ethical Issues

Ethical approval for the study was obtained from Rockview University, and permission was sought from relevant local authorities before data collection. Participants were provided with informed consent forms explaining the purpose of the study, voluntary participation, and their right to withdraw at any time. Confidentiality and anonymity were maintained by removing personal identifiers and securely storing data, while the research was conducted with honesty, transparency, and respect for participants’ rights.

## 4. Findings

### 4.1 Disruptions in Production Processes Caused by Prolonged Power Outages



Source: Field data, 2025

Fig 1: Extent to Which Power Outages Affect Production Output (n = 100)

Findings revealed that 24 respondents (24%) indicated that power outages affected production output to a very great extent, while 40 respondents (40%) reported a great extent of effect. Twenty-two respondents (22%) experienced minor disruptions, 10 respondents (10%) reported minimal effects, and 4 respondents (4%) indicated no effect at all. This demonstrated that power outages significantly affected production efficiency for most SMEs in the study.

Table 2: Descriptive Statistics on Disruptions in Production Processes Due to Power Outages (n = 100)

Statement	Mean	Std. Dev
Prolonged power outages are frequent in Lusaka District.	4.12	0.89
Power outages often occur during peak production hours.	3.94	0.95
Power outages significantly reduce daily production output.	4.05	0.87
Machines and equipment are frequently left idle due to outages.	3.88	0.91
Delayed customer orders are directly linked to power disruptions.	3.76	0.98

Source: Field data, 2025

The findings indicated that respondents agreed that prolonged power outages were frequent in Lusaka District, with a mean score of 4.12 and a standard deviation of 0.89. Power outages were also reported to often occur during peak production hours (mean = 3.94, SD = 0.95). Respondents further indicated that outages significantly reduced daily production output (mean = 4.05, SD = 0.87) and frequently caused machines and equipment to remain idle (mean = 3.88, SD = 0.91). Additionally, delayed customer orders were linked to power disruptions, with a mean of 3.76 and SD of 0.98. These results demonstrated that power outages substantially disrupted production processes among manufacturing SMEs in Lusaka District.

### 4.2 Effect of Power Outages on Operational Costs and Profitability

Table 3: Descriptive Statistics on the Effect of Power Outages on Operational Costs and Profitability (n = 100)

Statement	Mean	Std. Dev
Power outages have increased production costs (e.g., fuel for generators).	4.18	0.85
Frequent outages have led to higher equipment maintenance costs.	3.96	0.92
Power outages negatively affect profit margins.	4.05	0.88
SMEs spend a significant portion of revenue on alternative power sources.	3.87	0.94
Loss of raw materials/spoiled goods due to outages is a major cost factor.	3.78	0.97

Source: Field data, 2025

The results indicated that respondents agreed that power outages had increased production costs, with a mean of 4.18 and a standard deviation of 0.85. Frequent outages were reported to contribute to higher equipment maintenance costs (mean = 3.96, SD = 0.92). Respondents further indicated that power outages negatively affected profit margins (mean = 4.05, SD = 0.88) and that SMEs spent a notable portion of revenue on alternative power sources

(mean = 3.87, SD = 0.94). Additionally, losses due to spoiled raw materials and goods were recognized as a major cost factor (mean = 3.78, SD = 0.97). These findings demonstrated that power outages significantly increased operational costs and adversely affected the profitability of manufacturing SMEs in Lusaka District.

**Table 4:** One-Sample t-test on the Effect of Power Outages on Operational Costs and Profitability (n = 100)

Statement	Mean	Std. Dev	t-value	df	Sig. (2-tailed)
Power outages have increased production costs (e.g., fuel for generators).	4.18	0.85	14.59	99	0.000
Frequent outages have led to higher equipment maintenance costs.	3.96	0.92	10.65	99	0.000
Power outages negatively affect profit margins.	4.05	0.88	12.00	99	0.000
SMEs spend a significant portion of revenue on alternative power sources.	3.87	0.94	9.24	99	0.000
Loss of raw materials/spoiled goods due to outages is a major cost factor.	3.78	0.97	8.07	99	0.000

Source: Field data, 2025

The one-sample t-test showed that the mean scores for all five statements were significantly higher than the neutral value of 3 ( $p < 0.001$ ). This indicates that respondents agreed that power outages increased production costs ( $t = 14.59$ ), led to higher equipment maintenance costs ( $t = 10.65$ ), negatively affected profit margins ( $t = 12.00$ ), required spending a significant portion of revenue on alternative power sources ( $t = 9.24$ ), and caused losses due to spoiled raw materials ( $t = 8.07$ ). The results confirmed that power outages had a substantial effect on the operational costs and profitability of manufacturing SMEs in Lusaka District.

### 4.3 Coping Strategies Adopted by Manufacturing SMEs to Mitigate the Effects of Power Outages

**Table 5:** Coping Strategies Adopted by SMEs to Mitigate the Effects of Power Outages (n = 100)

Response Options	Frequency	Percentage (%)
Use of generators or alternative power sources	42	42%
Rescheduling production to off-peak hours	25	25%
Outsourcing production during outages	12	12%
Stockpiling raw materials or finished goods	10	10%
Reducing operational hours temporarily	8	8%
Other (installation of solar panels)	3	3%
<b>Total</b>	<b>100</b>	<b>100%</b>

Source: Field data, 2025

The results indicated that 42 respondents (42%) reported using generators or alternative power sources to cope with power outages. Twenty-five respondents (25%) rescheduled production to off-peak hours, while 12 respondents (12%) outsourced production during outages. Stockpiling raw materials or finished goods was reported by 10 respondents (10%), and 8 respondents (8%) temporarily reduced operational hours. Additionally, 3 respondents (3%)

indicated other strategies, specifically the installation of solar panels. Overall, the findings showed that SMEs adopted a variety of strategies, with generators being the most common method to mitigate the effects of power outages.

### 4.4 Recommendations for Improving Energy Reliability and Resilience of Manufacturing SMEs

**Table 6:** Measures to Improve Energy Reliability for SMEs (n = 100)

Response Options	Frequency	Percentage (%)
Installation of backup generators or alternative power sources	45	45%
Investment in renewable energy (e.g., solar, biogas)	30	30%
Upgrading electrical infrastructure and wiring	12	12%
Government-subsidized energy programs	7	7%
Partnership with energy service providers for uninterrupted supply	5	5%
Other (installation of energy-efficient machinery)	1	1%
<b>Total</b>	<b>100</b>	<b>100%</b>

Source: Field data, 2025

The findings showed that 45 respondents (45%) recommended installing backup generators or alternative power sources to improve energy reliability. Thirty respondents (30%) suggested investing in renewable energy such as solar or biogas, while 12 respondents (12%) emphasized upgrading electrical infrastructure and wiring. Seven respondents (7%) recommended government-subsidized energy programs, and 5 respondents (5%) supported partnerships with energy service providers. Additionally, 1 respondent (1%) proposed the installation of energy-efficient machinery as an alternative measure. Overall, the results indicated that SMEs prioritized backup power and renewable energy investments to enhance energy reliability.

### 5. Discussion of Findings

The study revealed that SMEs in Lusaka District are highly vulnerable to frequent power outages, which significantly disrupt production processes, particularly machinery-intensive operations. These disruptions reduced production output, forced firms to reschedule operations, and resulted in delayed deliveries and inefficiencies, with nearly two-thirds of respondents indicating moderate to significant production losses. The findings align with Chileshe and Manda (2023), Chikozho (2020), and Nkhata (2020) [38], and reflect broader economic implications noted by Adenikinju (2019) [1] and Kalenga (2021) [24]. Larger firms demonstrated relatively better resilience than smaller SMEs, consistent with Adeola and Boso (2014) and the African Development Bank (2021) [5], highlighting the importance of energy reliability for SME sustainability (ZESCO, 2023) [59].

The findings revealed that power outages substantially increased production costs among manufacturing SMEs, particularly expenditures on fuel for generators and alternative energy sources, as well as maintenance costs due to equipment wear and tear. Profit margins were negatively affected as reduced output combined with increased operational expenses, while significant revenue was diverted

toward generators, inverters, and fuel. These findings are consistent with Adeola and Boso (2014), Chileshe and Manda (2023), Hermanus (2018), the International Energy Agency (2014) [22], and ZDA (2022) [57], reinforcing that unreliable electricity directly undermines SME financial performance.

Losses due to spoiled raw materials and goods also emerged as a critical cost factor, especially for SMEs handling perishable or temperature-sensitive products, aligning with Kalenga (2021) [24] and NDRRMC (2016) [37]. Statistical results further confirmed that power outages significantly increased production costs, consistent with Adeola and Boso (2014) and Chileshe and Manda (2023), emphasizing the financial burden caused by energy unreliability among manufacturing SMEs in Lusaka District.

The findings revealed that manufacturing SMEs predominantly relied on generators and alternative power sources as coping strategies, followed by rescheduling production to off-peak hours, outsourcing production, stockpiling, and temporary reduction of operational hours, with a minority adopting solar energy solutions. These strategies align with Chileshe and Manda (2023), Hermanus (2018), Kapika and Eberhard (2013) [27], Nkhata (2020) [38], Kalenga (2021) [24], Adeola and Boso (2014), and the African Development Bank (2022). The effectiveness of coping strategies was generally positive, consistent with Chikozho (2020), indicating that SMEs were able to mitigate some negative effects of power outages.

The study findings indicated that SMEs prioritized installing backup generators, investing in renewable energy, upgrading electrical infrastructure, government-subsidized energy programs, partnerships with energy service providers, and adopting energy-efficient machinery to enhance energy reliability. These recommendations align with Chileshe and Manda (2023), Hermanus (2018), African Development Bank (2022), UNDP (2019) [50], Kapika and Eberhard (2013) [27], ZESCO (2022) [58], Adenikinju (2019) [1], IMF (2021) [21], Tanzania Electricity Supply Company (2019), Adeola and Boso (2014), and Chikozho (2020), highlighting both enterprise-level and policy-level approaches to improving resilience against prolonged power outages.

## 6. Conclusion

In conclusion, prolonged power outages in Lusaka District significantly disrupted production efficiency in manufacturing SMEs, causing workflow delays, reduced equipment utilization, and scheduling challenges, which in turn affected operational performance and profitability through increased costs for generators, maintenance, and losses from spoiled materials. SMEs adopted coping strategies such as standby generators, production rescheduling, stockpiling, and outsourcing, while investments in renewable energy and energy-efficient practices further enhanced operational resilience. Strengthening energy reliability through policy support, infrastructure upgrades, and sustainable energy solutions is essential to safeguard productivity, reduce operational costs, and ensure long-term business continuity, directly addressing the study objectives of assessing production disruption, cost impacts, profitability, and coping strategies.

## 7. Recommendations

1. The government through the Ministry of Commerce, Trade and Industry should provide subsidies or tax incentives covering up to 30% of the cost of purchasing and installing solar power systems or other renewable energy solutions for registered manufacturing SMEs to reduce production disruptions caused by prolonged power outages.
2. SME owners should adopt energy-efficient production methods and reschedule operations to off-peak hours to minimize the effect of power outages and maintain productivity.
3. SMEs should implement measures such as stockpiling critical raw materials, diversifying suppliers, or outsourcing production during high-risk periods to safeguard profit margins during power disruptions.
4. ZESCO and relevant authorities should upgrade electrical infrastructure, ensure reliable energy distribution, and provide timely and accurate load-shedding schedules to help SMEs plan operations effectively.
5. SMEs should partner with independent power producers and invest in renewable energy solutions, such as solar or hybrid systems, to strengthen resilience and ensure sustainable business operations.
6. Banks and other financial institutions should develop low-interest loan products specifically for SMEs to invest in energy resilience technologies, such as solar power systems and backup generators, making these solutions financially accessible.

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