Electricity Outages and Firm Choices in Ghana: A Case Study of Manufacturing Firms in Kumasi

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ABSTRACT

The research investigates the effect of electricity outages on the decision-making and sales performance of 288 small-scale enterprises in the Greater Kumasi area of Ghana. Quantitative methods were employed to analyze data derived from closed-ended questionnaires. Through the application of Chi-square tests and Pearson's correlation analysis, the study explored the associations between electricity disruptions, firm decision processes, and performance metrics. Descriptive statistics, notably the calculation of means, were utilized to encapsulate firms' experiences and illuminate prevalent patterns in outage frequency, production losses, and adaptive strategies. The results of the study indicate that the majority of firms encountered power interruptions during operations, prompting the adoption of generators and plants to maintain production continuity, while a minority opted for outsourcing. Furthermore, alternative electricity sources, predominantly dependent on fuel-powered generators and plants, escalate production costs, thereby diminishing output and sales revenue. These fuel-powered energy solutions also pose significant environmental risks, underscoring the necessity for firms to reconsider investments in solar energy, which presents a more cost-effective, viable, and environmentally sustainable energy alternative. Considering the substantial overhead expenses associated with such large-scale endeavors, firms in the Greater Kumasi area could collaborate to establish, co-own, and operate a shared solar power plant. This initiative would reduce dependency on the national grid, offering a more reliable, cost-efficient, and sustainable energy source to enhance firm productivity and revenue, while promoting clean energy for sustainable community development.

Keywords: electricity outages; production cost; production decision; sustainable energy; output performance

INTRODUCTION

Electricity is crucial for the production processes of medium and small industries and vital for sustainable industrial growth worldwide. However, Ghana faces challenges with the inconsistent power supply. The country's electricity comes from hydroelectric, fossil-fuel, and renewable sources, essential for its economic growth amid rapid industrialisation. About 78% of Ghanaians, including 17% in rural areas, have access to national grid, with a per capita consumption of 358 kWh. All regional capitals are connected to the grid (Asuming, 2021). In 2013, Ghana's per capita electricity use was 382.31 KWh, with about 50% used by households for activities like ironing, air conditioning, and refrigeration. Households often use high-energy appliances like second-hand refrigerators and air conditioners. A small portion of their electricity is for lighting. In 2013, electricity demand grew by 1.7% in the industrial sector, 33% in non-residential, and 15.4% in residential sectors.

In response to the escalating demand for electricity, an increase in supply is anticipated. Electricity supply in Ghana is insufficient due to inadequate infrastructure investment, low water levels in the Akosombo Dam, and disruptions like damage to the West Africa Gas Pipeline. Other factors include lack of turbine fuel, poor credit risk of the Electricity Company of Ghana, and low output from the Bui hydroelectric station. Electricity demand in Ghana outweighs the supply side leading to problems such as load shedding, laying off workers, high operational costs and closing of businesses (Mensah & Okyere, 2022). These in turn leads to a fall in production.

In order to address the deficit arising from heightened electricity demand and low supply, the government has implemented strategic initiatives aimed at cultivating a robust and efficient energy sector, thereby ensuring the provision of sustainable power for the economic framework. For example, in the 2022 national budget, some 65% of the total fiscal allocation was directed towards the Ministry of Power (Government of Ghana, 2022). Furthermore, efforts are underway to construct new small power generations, transmission, and distribution infrastructures. The Ghanaian government has also commissioned emergency power plants with a cumulative capacity of 1000MW to be operational in Ghana. Additionally, the Kpone thermal plant and the Tico plant unit are undergoing significant expansions.

The unreliability of electricity supply represents one of the most significant challenges facing Ghana's economy. Power outages and fluctuations occur about 9.4 times monthly in Ghana, particularly impacting manufacturing and commercial sectors, sometimes lasting long durations (Adu & Denkyirah, 2021; World Bank Enterprise Survey, 2013). Manufacturing, a key national economic sector employing 61% of urban labor (ILO in UNESCO, 1995), faces reduced productivity and efficiency due to unreliable power (Mensah & Okyere, 2022). Electricity is crucial for manufacturing processes, making these firms vulnerable to supply shortages (Adu & Denkyirah, 2021; Mensah & Okyere, 2022). This study explores strategic responses to power issues, examining effects on production, sales, costs, and decision-making in the Kumasi Metropolitan area. Key research questions include: What are the effects of outages on production and sales? How do they influence production costs and decision-making? Are worth examining. Together these questions analyse how each measure of electricity outages affect firm's productivity, in both its technical and allocative efficiency, and whether various alternatives to power generation are effective in mitigating the potential productivity losses associated with electricity outages.

The study seeks to fill the research gap in sustainable access of energy for manufacturing industries in Ghana. Dramani and Tewari (2010) examined the short and long-run elasticities of residential demand for electricity in Ghana. Previous studies focused on the demand side using macroeconomic indicators, neglecting the supply side. Abebrese (2010) found firms could adapt to pre-announced electricity rationing, reducing its impact. This study explores how unexpected electricity outages affect firm productivity and sales. Adu and Denkyire (2021) showed improved energy access boosts small enterprise performance in sub-Saharan Africa, emphasizing energy access as crucial for business productivity. There's a lack of empirical data on small firms' responses to energy access in sub-Saharan Africa, highlighting the need for micro-level analyses on energy constraints and firm growth, which this study addresses.

The study is structured as follows. Section 2.0 provides the theoretical and empirical foundation by examining electricity outages and firm performance. Section 3.0 outlines the study's methodology. Section 4.0 discusses data analysis and results. Section 5.0 concludes with a summary of findings, conclusions, and recommendations.

THEORETICAL REVIEW AND EMPIRICAL REVIEW

This Section details the review of literature on electricity outages and firm choices. Issues such as definition of concepts, electricity outages and firm choice models, the effects of electricity outages on firms and alternative energy theories are discussed in this chapter. This chapter finally reviews related empirical findings.

Neely et. al., (1995), defines firms' performance as the process of assessing the actions and effectiveness of a firm. Bititci et. al., (1995), also argues that firms' performance can also be described as the process whereby a firm manages its performance to match its functional strategies and objectives. In this study, firms' performance is defined as how effectively a firm accomplishes a given task using its available resources to produce a given level of output and level of sales made. In this study, electricity outage is defined following the definition of (CEIDS, 2001) as the complete absence of electricity at the users' end either planned or unexpected. Firm choices in this study refers to decisions that firms undertake to guard themselves against losses because of electricity fluctuations.

Theoretical Inspirations

This study was theoretically framed by a nested theories triangulating the revealed preference approach, marginal cost theory and the incomplete backup theory.

Revealed Preference (Investment) Approach

Caves et al. (1992) used the revealed preference approach to assess outage costs for large manufacturers. Outages often cause economic losses, affecting some firm tasks more than others. For instance, companies like EVERPURE, which rely on continuous electricity for machinery, suffer significant losses during outages, potentially rendering raw materials useless. To mitigate these effects, firms invest in alternatives like generators, solar panels, or biomass. Managers often secure power for the firm's most vulnerable units.

Marginal Cost Theory (Bental and Ravid, 1982)

Bental and Ravid (1982), were the first to point out that the cost of electricity outages to a firm can be estimated using data on backup generators. The study assumes that firms act rationally and hedge to ensure themselves against damages that may be caused by electricity fluctuation by investing in backup generating plants which is expensive and may not be economically viable if it is not well planned. Firms must choose the optimal amount of backup power by considering its energy load and the damage the remaining unserved energy would cause. Therefore, the firm’s problem is to decide and choose the optimal degree of backup that minimizes cost.

Incomplete Back-up theory

Beenstock et al. (1997), shows that firms may incur losses as result of incomplete backup in the event of power fluctuation or electricity outages. The basic assumption underlying this theory implies that, firms will ensure persistent electric service to the most susceptible units by investing in various backup operators such as generators, solar panels and biomass. The optimal level of scale of this backup mostly depends on the operating cost (generators, solar panels and biomass), level of vulnerability and the expected fluctuation time. Thus, incomplete backup theory allows for a distinction between estimation of total and complete electricity outages cost. To conclude with, the higher the backup capacity, the higher will be the mitigated loss and the lesser will be the unmitigated loss in the event of electricity outages.

Electricity is crucial for industrial production, and unreliable supply limits productivity. Frequent outages cause output losses and delays, prompting firms to invest in backup generation if the benefits outweigh the costs. Investment decisions depend on firm characteristics like size, sector, and location. Larger firms invest more due to higher capital and productivity. Strategies to manage outages include halting production, running shifts, reducing capacity, or outsourcing. These adaptations help minimize losses and sustain operations in energy-constrained environments.

Analytical frameworks

The study's framework on Electricity Outages and Firm Choices in Ghana triangulates the Revealed Preference Approach, Marginal Cost Theory, and Incomplete Backup Theory to explore firm responses to electricity outages via adaptive investment and operational decisions. Using the Revealed Preference Approach, it assumes firms’ investment choices in generators, solar panels, or backup systems indicate their implicit valuation of outage costs. Marginal Cost Theory suggests firms optimize backup investment where the marginal cost equals the marginal benefit from avoided losses. Incomplete Backup Theory notes firms provide partial backup due to financial and operational limits, prioritizing critical production units. The framework uses Chi-square analysis to test the link between outages and firm characteristics like size, sector, and investment, and correlation analysis to assess relationships between outage frequency, production, and sales. Base on the above the three underpinning principal elements of this framework are:

1. firm rationality in investment decisions under energy constraints,
2. optimization of cost–benefit trade-offs in outage management,
3. partial adaptation reflecting heterogeneous firm capacities.

Together, these principles provide a contextual analytical structure for empirically linking electricity unreliability to firms' adaptive choices and performance outcomes in the Kumasi developing economy's small scale manufacturing sector.

Empirical Review

A growing number of empirical istudies, including those conducted by Muneeza (2013), Allcott, Collard-Wexler, and O'Connell (2016), Fisher-Vanden (2015), Mensah (2016), Adu and Denkyirah (2021), Asuming (2021), as well as Mensah and Okyere (2022), have systematically analyzed the impact of electricity outages on firm behavior within both developed and developing nations. The comprehensive and consistent outcomes of these studies demonstrate that electricity outages significantly diminish firm productivity, output, and profitability while also shaping firms' investment decisions and adaptive strategies (Allcott et al., 2016; Fisher-Vanden, 2015; Mensah, 2016). The research indicates that firms often resort to employing backup generators or alternative energy solutions; however, such measures only partially mitigate the production and financial losses attributed to unreliable electricity supplies (Allcott et al., 2016; Abeberese, Ackah, & Asuming, 2021). Moreover, smaller enterprises and energy-intensive sectors are particularly susceptible to these disruptions (Cole, 2018; Fisher-Vanden, 2015). The evidence further suggests that recurrent outages adversely affect investment behaviors, deterring expansion and technological advancements, thereby hindering long-term competitiveness and growth (Abeberese et al., 2021; Cole, 2018). Collectively, these scholarly works underscore a persistent research gap concerning the disparate capacities of firms—especially small and medium-sized enterprises (SMEs)—to absorb and adapt to electrical disruptions under varied institutional and infrastructural conditions prevalent in sub-Saharan Africa (Abeberese et al., 2021; Abiodun, 2022).

Also, Fisher-Vanden (2015) examined electricity shortages and firm productivity using a large panel of Chinese industrial firms; she found that unreliable electricity forces firms to re-optimize input mixes and outsource some intermediate inputs, but these adjustments still raised unit production costs substantially.

Similarly, allcott et al. (2016) studied Indian textile plants facing scheduled "power holidays" and found that while firms mitigated output losses through flexible adjustment of inputs and generator use, energy costs rose and productivity nevertheless declined. Muneeza (2013) showed inter-industry heterogeneity in India—steel mills suffered output and profit losses from outages while rice mills were better able to adapt by changing input mixes. In a multi-country sub-Saharan Africa analysis, Mensah (2016) reported a strong negative association between outage intensity and firm productivity using World Bank Enterprise Survey panel data.

More recent Ghana-focused work by Abeberese, Ackah, and Asuming (2021) uses exogenous variation from rationing programmes to show that reducing outages would meaningfully increase firm productivity and that common coping strategies (e.g., backup generation) do not fully insulate firms from outage impacts. Complementary Ghanaian studies (e.g., Sosi & Atitianti, 2021) similarly document larger performance penalties for firms without reliable backup systems. These findings justify a focused study of small-scale manufacturing firms in the Greater Kumasi Area to understand how outages affect both production choices and sales performance in a context where many firms lack capacity for full adaptation.

The synthesis of the reviewed literature indicates a recurring trend wherein electrical power outages substantially impede the productivity, profitability, and expansion of firms, with pronounced effects on small and medium-sized enterprises (SMEs) in developing regions, such as Ghana. The research focused on Ghana underscores that frequent power outages diminish competitiveness, constrain industrial growth, and impede innovation within the manufacturing sector (Adu & Denkyirah, 2021; Asuming, 2021; Mensah & Okyere, 2022). Notwithstanding these findings, a notable gap persists in the literature concerning the strategic responses of micro- and small-scale manufacturers situated in regional industrial zones—specifically the Greater Kumasi Area—regarding their production, sales, and investment decisions amidst recurrent power outages. Consequently, future research endeavors in Ghana are advised to utilize firm-level panel data and adopt mixed-methodological frameworks to elucidate the dynamic behavioral, technological, and policy adaptation strategies that underpin firms' resilience to electrical power instability within the context of evolving local energy markets.

METHODS

This study adopts a quantitative research strategy, with correctional design. The strategy was chosen because it allows for systematic measurement of firms' experiences and facilitates the identification of statistical relationships between electricity supply interruptions and firm's output (Anlimachie, 2019; Bryman, 2012). The quantitative approach also provides a structured basis for generalizing findings across similar industrial settings, thereby supporting evidence-based recommendations for policy and practice (Bryman, 2012).

The study Design

The design is cross-sectional in nature, capturing owners and managers of small and medium production firms' experiences and responses to electricity outages and their impact. The study cross-sectional research design guided the logical process of data collection, organization, and analysis. It linked the empirical evidence obtained from firms to the research objectives in a coherent and methodical sequence (Anlimachie, 2019; Bryman, 212). The chosen design integrates descriptive and analytical components — descriptive to profile firms and their outage experiences, and analytical to assess the impact of these outages on firms' production choices and sales performance (Bryman, 2012). The study focussed on primary quantitative data, enables direct engagement with firm owners and managers, ensuring that the voices and lived experiences of business actors form the basis of the empirical analysis Anlimachie & Avoada, 2020).

Sampling Techniques

A purposive sampling technique was employed to designate the Greater Kumasi Industrial Area of Ghana as the focus of this study. This site was intentionally selected due to its rapidly industrializing nature and its strategic position within Ghana's manufacturing sector. The study aimed to specifically target small-scale and medium-sized enterprises, which significantly influenced the selection of the study location. The industrial landscape of Kumasi is predominantly characterized by a diverse array of small-scale and medium-sized enterprises that rely heavily on electricity for daily operations. Despite its industrial potential, compared to other industrial zones in Ghana, such as the Tema Industrial Area, the Greater Kumasi Industrial Area is frequently subjected to interruptions in electricity supply (Avaoda et al., 2021; Ghana Statistical Service–GSS, 2021).

A cluster sampling technique was subsequently applied to segment the Greater Kumasi Industrial Area into ten zones, including Adum, Adwase, Atonsu, Buoho, Ahinsan, Akyease, Asafo, Oduom, Tech, and KNUST areas. Approximately 80% of the selected enterprises were sole proprietorships. A simple random sampling procedure was then utilized to select the owners or production managers of 30 firms from each cluster. Recent studies on manufacturing enterprises in Ghana suggest that simple random sampling is suitable only when the target firms exhibit homogeneity in key attributes; otherwise, purposive or stratified sampling techniques are more appropriate (Asafo-Adjei et al., 2023). In total, the study targeted the owners or production managers of 300 firms. This approach was considered suitable because the study focused on small-scale and medium-sized firms with specific characteristics—those utilizing electricity from the national grid as a primary energy source and experiencing frequent power outages (Bryman, 2012). The technique ensured equitable representation of all small-scale and medium-sized firms within the study area, facilitating the inclusion of enterprises whose experiences directly align with the research objectives. The sample size was determined using Yamane's (1967) simplified formula for sample estimation, detailed as follows.

$$n = \frac{N}{1+N(e)^2}$$

Where *n* represents the sample size, *N* the population size, and *e* the level of precision. Based on World Bank (2013) data indicating 729 manufacturing firms in Ghana and a 5% margin of error, the estimated sample size was 258 firms. To allow for incomplete or non-responses, the sample size was increased to 300, out of which 288 valid responses were obtained for analysis. The study participants included owners and managers of small-scale and medium-scale manufacturing firms operating in sectors such as food processing, printing, beverage and snack production, water bottling, and plastics manufacturing. Purposive sampling is justified when the objective is to focus on "information-rich" cases that directly meet the study criteria (Bryman, 2012; Patton,

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2015). In contexts where firms of interest are those experiencing a particular phenomenon (in this case, power outages), purposive sampling ensures relevance and efficiency.

Data were collected through structured questionnaires administered via interviews and self-completion formats, depending on respondents' literacy levels (Blozis & Villarreal, 2024). The questionnaire was designed to capture both quantitative and qualitative aspects of firms' experiences. It included closed-ended questions to generate numerical data on outage frequency, cost implications, and sales performance, and open-ended questions to allow respondents to express perceptions and coping strategies in their own words.

Quality assurance

The study used robust questionnaire validations to ensure validity and reliability Hawkins et al., 2020). The process included: Content/Face Validity, where experts reviewed items for relevance; Pilot Testing, with 20 firms to assess comprehension and translation; Construct Validity and Reliability Testing for internal consistency; and BioMed Central Language and Cultural Adaptation, translating to Twi to ensure conceptual equivalence (Rosas, et al., 2023).

Self-reported data, while convenient, are biased by factors like social desirability and recall ((Blozis & Villarreal, 2024).). Therefore, in addressing possible biases associated with this, anonymity was assured, questionnaires were neutrally worded, and questions were anchored to recent events. Surveys were conducted in English or Twi, with face-to-face interviews for better comprehension. Data were cross validated with secondary sources, and statistical checks were used to identify biases. Non-response bias was managed by replacing non-respondents from the same group. Studies highlight the importance of these strategies in maintaining data validity (Blozis & Villarreal, 2024).

DATA ANALYSIS STRATEGY

Chi- square analysis

To examine how electricity outage, affect firm choices, the study uses firm level qualitative variables acquired via questionnaires to analyse how electricity outage affects firms' choice. Here Chi-square analysis is used in finding a statistical relation among firm level variables and firms' choice (a qualitative variable).

The chi-square test of independence is used to determine whether there is a significant relationship between two variables. It is intended to test how likely it is that an observed distribution is due to chance. The chi-square statistic **is** computed as follows. The expected frequency counts are computed separately for each level of one categorical variable at each level of the other categorical variable. Compute r*c expected frequencies according to this formula:

$E_{r,c} = (n^{r \times n_c})$ (3.2) n

$E_{r,c}$ = expected frequency count for level r of variable A and level C and of variable B.

n_r= total number of sample observations at level r of variable A n_c= total number of sample observations at level C of variable B n = total sample size

Pearson Chi-square statistic

$\chi^2 = \sum \frac{(O-E)^2}{}$, (3.3) E

Where χ^2 = Test statistic that approaches a χ^2 distribution, O = Frequencies observed and E = Frequencies expected (asserted by the null hypothesis)

Null hypothesis: Assumes that there is no association between the two variables.

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Alternative hypothesis: Assumes that there is an association between the two variables.

Hypothesis testing: If the calculated value of the Chi-Square test is greater than the table value, we will reject the null hypothesis. If the calculated value is less, then we will accept the null hypothesis.

P-value is the probability of observing a sample statistic as extreme as the test statistic. Since the test statistic is chi-square, use the Chi-Square Distribution Calculator to assess the probability associated with the test statistic.

If the sample findings are unlikely, given the null hypothesis, the researcher rejects the null hypothesis. This involves rejecting the null hypothesis when the p-value is less than significance level.

Correlation Analysis

Correlation analysis is a method of statistical evaluation used to study the strength of a relationship between two, numerically measured, continuous variables. (Between an independent variable and a dependent variable). The variables are said to be correlated when the movement of one variable is accompanied by the movement of another variable. A strong or high correlation means that two or more variables have a strong relationship with each other, while a weak or low correlation means that the variables are hardly related. Statistical software is used to determine the relationship between the variables present. The statistical process produces a correlation coefficient that tells us the association. This is termed the Pearson's correlation coefficient and is given by;

$$r = \frac{\sum(X-\bar{X})(Y-\bar{Y})}{\sqrt{\sum(X-\bar{X})^2 \times \sum(Y-\bar{Y})^2}} \qquad (3.4)$$

where $\bar{Y}$= sample mean for variable Y and $\bar{X}$= sample mean for variable X.

The Pearson's correlation coefficient is a measure of the strength of the association between the two variables. (X and Y). The correlation coefficient lies between ($-1 \leq r \leq +1$). The value of -1 represents a perfect negative correlation, which means that as the value of one variable increases, the other decreases. While a value of +1 represents a perfect positive relationship meaning that as one variable increases in value, so does the other. A value of 0 means that there is no relationship between the variable being tested.

Mean / Average

A measure of central tendency either of a probability distribution or of a random variable characterized by that distribution. The sample mean is given by;

$$\bar{x} = \frac{\sum x}{n} \qquad (3.5)$$

DATA PRESENTATION AND ANALYSIS

This section presents and discusses the results of the study. The chapter shows the findings in tabular presentation and the chi-square statistic for the statistical relationship among the variables displayed underneath with the interpretation of results and discussion thereof. The summary of firms which participated in the survey is summarized in Table 4.1 below.

Table 4.1: The type of business in which firms operate and electricity reliability

Variable	Freq.	Percent
Business Type		
Food processing	44	15.28%
Printing press	81	28.13%

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Water Companies	29	10.07%
Soft drinks, Beverages and snacks	50	17.36%
Plastics	20	6.94%
Welders, sliding doors	49	17.01%
Others	15	5.21%
Total	288	100%
Use Electricity in Business Operation		
Yes	288	100%
No	0	0%
Reliability of Electricity		
Reliable	103	35.76%
Not Reliable	171	59.38%
More Reliable	7	2.43%
Most Reliable	7	2.43%
Total	288	100%

From Table 4.1 it can be observed that, majority of firms (28.13%) operated in printing press business, (17.36 %) operated in soft drinks, beverages and snacks. With regards to respondents who operated as welders, about (17.01%) and a little above (15.28%) operated in food 20 processing. Water producing companies represented a percentage of (10.07), Plastics was (6.94%) and a small portion also represented (5.21%). Thus, a greater percentage (28.13) as against the least recorded respondent's "Others" of (5.21%).

These firms were then enquired if they do experience power outages during daily operations, and if they do, how reliable is the electricity from the power grid. All firms interviewed (100%) used electricity in their production operation. It is seen that about 35.76% of the firms' respondents that electricity was reliable to them. Few (2.43%) of the firms however responded that, electricity supply from the power grid was more reliable. It is therefore clear that, majority of our respondents (59.23%) stated that electricity is not reliable to them, and hence, the study probed into the nature of power supply received by firms regarding if they do experience power outages during work/operations and if they do use any alternate source of power should there be an outage in electricity power supply.

Table 4.2: Years of establishment and sales made

Variable	**Observation**	**Mean**	**Minimum**	**Maximum**
Years of Establishment	287	5.5yrs	2.5yrs	17yrs
Sales made when supply of electricity is constant per month (in GH₵)	288	76,937.43	80.00	1,000,000.00

Pearson's correlation coefficient between years of establishment and sales = 0.2398

From Table 4.2, the mean years of establishment of firms who were respondents was five and half years (5.5). The minimum years of establishment was two and a half years (2.5), and the maximum was 17 years. This shows

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that firms responses on how electricity outages affect production would be a good reflection of the situation on the ground. Furthermore, when there is constant supply of electricity, firms make an average monthly sale of GH₵76,937.43 the maximum sales made in a month is GH₵1,000,000 and the minimum sales made in a month is GH₵80. The Pearson's correlation coefficient for firms' years of establishment and sales made when there is constant electricity supply is 0.2398. This is positive, and hence, there is a positive association between these two variables. This implies that, more sales are associated with more years of firms' existence in the market.

Table 4.3: Experiencing power outages and the use of alternative sources

	Yes		**No**	
	Freq.	**%**	**Freq.**	**%**
Experience power outage during operation	280	97.22%	8	2.78%
Use of alternative sources Variable	193	68.20%	90	31.80%

Pearson's correlation coefficient between outages and alternate energy use = 0.1744

From Table 4.3, almost all of the firms (97.22%) experience power outage during operation, and as a result, 68.2% resort to the use of alternate power sources. The correlation coefficient between firms' outage experience during operation and use of alternative electricity was 0.1744. This is positive, implying that, firms who experience outages tend to use alternate electricity sources.

Rate of power outages experienced by manufacturing firms.

Having established that most of the firms experience power outages, the study further enquired into how often they experience these outages and the duration of these outages on average. The rate of occurrence of power outages experienced by firms is presented in Table 4.4 and the duration with which these outages last is summarized in Table 4.5.

Table 4.4 Frequency of power outages experienced by firms

			How Often Does Power Outages Occur					
	very often		**Often**		**Not often**		**Total**	
Business Type	Freq	%	Freq	%	Freq	%	Freq	%
Food processing	8	2.8%	18	6.3%	18	6.3%	44	15.4%
Printing press	15	5.3%	22	7.7%	43	15.1%	80	28.1%
Water Companies	4	1.4%	20	7.0%	5	1.8%	29	10.2%
Soft drinks, Beverages	6	2.1%	29	10.2%	14	4.9%	49	17.2%
Plastics	5	1.8%	13	4.6%	2	0.7%	20	7.0%
Welders, sliding door	14	4.9%	13	4.6%	21	7.4%	48	16.8%
Others	4	1.4%	11	3.9%	0	0.0%	15	5.3%
Total	**56**	**19.6%**	**126**	**44.2%**	**103**	**36.1%**	**285**	**100.0%**

Pearson chi2 (12) = 45.2738   Prob> (Chi2) = 0.000

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From Table 4.4, although a few (19.6%) of the firms experience power outages very often, a lot of the firms (44.2%) experience it often whiles (36.1%) do not experience it often. In all, majority 63.8% of firms experience significant occurrences of power outages. Considering the 44.2% of firms that experience power outages often, majority (10.2%) were from soft drinks and beverage production. Also, printing press constituted the majority (15.1%) of the firms that did not experience power outages often. In addition, Amadu et al (2016) revealed that close to 43% of firms experienced outages often, 48% experienced outages very often, whilst about 9% experienced power outages not often.

Pearson chi-squared test is a statistical test applied to sets of categorical data to evaluate how likely that any observed difference between the sets arose by chance. It is suitable for unpaired data for large samples. The null hypothesis states that there is no difference between the distributions. Since the probability value of the chi-squared statistic, which is 0.000, is less than 5% critical error, we reject H_0, and hence there is a significant difference between the distribution.

Table 4.5: The duration of outage experienced by firms.

BUSINESS TYPE	**Duration of outages**									
	LESS THAN AN HOUR		**1 TO 3 HOURS**		**4 TO 12 HOURS**		**ABOVE 12 HOURS**		**Total**	
	FREQ.	%	FREQ.	%	FREQ.	%	FREQ.	%	FREQ.	%
Food processing	6	2.1%	28	9.8%	9	3.1%	1	0.3%	44	15.4%
Printing press	13	4.5%	56	19.6%	11	3.8%	0	0.0%	80	28.0%
Water Companies	3	1.0%	14	4.9%	12	4.2%	0	0.0%	29	10.1%
Soft drinks, Beverages	3	1.0%	40	14.0%	6	2.1%	0	0.0%	49	17.1%
Plastics	1	0.3%	13	4.5%	6	2.1%	0	0.0%	20	7.0%
Welders, sliding door	4	1.4%	36	12.6%	9	3.1%	0	0.0%	49	17.1%
Others	0	0.0%	9	3.1%	5	1.7%	1	0.3%	15	5.2%
Total	30	10.5%	196	68.5%	58	20.3%	2	0.7%	286	100.0%

Pearson chi2 (18) = 32.4235 Prob> (Chi2) = 0.020

The study revealed that power outages were frequent and lasted long. From the above table, it's clearly seen that the dominant period of power outages experienced by majority of the firms (68.5%) is from a duration of 1hour to 3 hours. Amadu et al., (2016) also found out that, close to 35% of industries experienced outages lasting 0-1 hour, 56% experienced outages lasting 2-4 hours whilst about 9% experienced outages lasting for more than 5 hours. Just a handful of firms (0.7%) experience power outages above 12 hours. Since the probability value of the chi-squared statistic, which is 0.020, is less than 5% critical error, we reject H_0, and hence there is a significant difference between the distribution.

Table 4.6: Pre-information of power outages to firms

Variable	**Freq.**	**Percent**
We are pre-informed	2	0.7%
They just happen abruptly without any consent	284	99.3%
Total	286	100%

From the table above, majority (99.3%) revealed that power outages happen abruptly whiles just a few (0.7%) revealed that they were pre-informed before the occurrences of power outages. Amadu et al (2016) found out that 73% of the outages were unforeseen, whilst 27% were planned.

Electricity Outage and firm choice

Abebrese (2013) found that electricity supply and prices affect firm's production choice. Vanden et. al., (2014) found that, most firms resort to other production mix to re-optimise output. The study therefore enquired firms' responses to power outage as to whether they use alternative power source such as generator/plant/solar or they outsource the production process.

Table 4.7: Firms response to power outages

Experience power outage during operation	Generator & Plants		Outsource		Solar		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Yes	191	94.09%	3	1.48%	6	2.96%	200	98.52%
No	2	0.99%	1	0.49%	0	0.00%	3	1.48%
Total	193	95.07%	4	1.97%	6	2.96%	203	100.00%

Pearson chi2 (4) = 20.3692 Prob> (Chi2) = 0.000

From the table 4.7, the total number that experience abrupt power outage during operation is 200 representing 98.5% of firms. Almost all of the firms (94.09 %) that experience power outage resort to the use of generators so as to continue production. Also, few (1.48 %) firms outsource their work during power outages. The small fraction of firms outsourcing output was in line with the findings of Vanden et. al., (2014) that outsourcing is very costly. In addition, a small fraction of firms (2.96 %) uses solar power source for lightning purposes. From the findings in Table 4.7, majority of firms using alternate energy source such as generator, plants and solar involve huge investment in acquisition and operational cost as well. Since the probability value of the chi-squared statistic, which is 0.000, is less than 5% critical error, we reject H_0, and hence there is a significant difference between the distributions.

The cost of using an alternate power source for business operation during power outages was enquired with the results presented in Table 4.8.

Effect of electricity outage on the cost of production

Table 4.8: Average monthly cost incurred in using alternative power-source

Monthly cost incurred in using alternative power-source for production (in GH₵)				
Business Type	**Observation**	**Mean**	**Minimum**	**Maximum**
Food processing	42	1174.524	150	8500
Printing press	46	471.3043	30	10000
Water companies	29	3551.724	200	15000
Soft drinks	44	1243.864	80	10000
Plastics	15	452	30	2000
Welders	14	505.7143	100	1200
Others	6	300	100	600

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Due to frequent power outages and the crucial role of electric power to their operations, firms have to obtain, run and maintain alternative power-sources such as standby generators and plants which imposes additional costs. As shown in Table 4.8 above, the study found that majority of firms spend between GH¢15,000 and GH¢10,000 to run their alternative power supply. The findings of Amadu et al (2016) was no different from the study's findings as he found that industries spend between fifteen million cedis and seven hundred and seventeen million cedis annually to run their standby power supply systems,

Vanden et. al., (2014) argues that firms therefore resort to other production mix. Due to the costly nature of alternate power source, firms may operate their machines differently than when there was power supply from the grid. Thus, firms were enquired as to how their machines are operated when running on an alternate power-source, with the findings presented in Table 4.9 below.

Table 4.9: Capacity of Usage of equipment in relation with electricity from Grid and alternative energy sources.

	Approach of Operation							
Business Type	All machines are operated		Few machines are operated		Normal lighting and fan system		Total	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Food processing	18	9.0%	23	11.5%	1	0.5%	42	21.0%
Printing press	17	8.5%	31	15.5%	0	0.0%	48	24.0%
Water Producing Companies	13	6.5%	15	7.5%	1	0.5%	29	14.5%
Soft drinks, Beverages	30	15.0%	14	7.0%	0	0.0%	44	22.0%
Plastics	6	3.0%	9	4.5%	0	0.0%	15	7.5%
Welders, sliding door	4	2.0%	10	5.0%	1	0.5%	15	7.5%
Others	2	1.0%	5	2.5%	0	0.0%	7	3.5%

Total 90 45.0% 107 53.5% 3 1.5% 200 100.0% Pearson chi2 (12) = 19.2544 Prob> (Chi2) = 0.043

From Table 4.9, about 53.5% of firms operate with few machines when there are electricity outages and they are using alternative sources of electricity. Also, less than half of the firms (45%) operate with all machines when there are outages. Soft drinks and beverages firms use all machines often during outages (15.0%), followed by food processing (9%). Also, a majority of printing press (15.5%) use few machines during outages. Since the probability value of the chi-squared statistic, which is 0.043, is less than 5% critical error, we reject H_0, and hence there is a significant difference between the distribution.

Despite the huge investment and operation cost in using these alternate power-sources, they are susceptible to failures. The occurrence of failure from the use of these alternate power sources is presented in Table 4.10.

Table 4.10: Experienced power failure from alternate power source

	Yes		**No**		**Total**	
Business Type	Freq	%	Freq	%	Freq	%
Food processing	20	10.1%	22	11.1%	42	21.1%
Printing press	41	20.6%	9	4.5%	50	25.1%

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Water Producing Companies	10	5.0%	19	9.5%	29	14.6%
Soft drinks, Beverages	10	5.0%	33	16.6%	43	21.6%
Plastics	6	3.0%	9	4.5%	15	7.5%
Welders, sliding door	13	6.5%	2	1.0%	15	7.5%
Others	4	2.0%	1	0.5%	5	2.5%
Total	104	52.3%	95	47.7%	199	100.0%

Pearson chi2 (6) = 45.8240 Prob> (Chi2) = 0.000

From Table 4.10, it can be seen that more than half of the firms (52.3%) experienced power failure when operating with alternative source of electricity. Also, about 47.7% did not experience any failure when operating with the alternative source of electricity. This power failure in operation affects printing press (20.6%) and food processing (10.1%) more than any of the other firms. Since the probability value of the chi-squared statistic, which is 0.000, is less than 5% critical error, we reject H_0, and hence there is a significant difference between the distribution.

The dynamics of power outage and how it affects the operations of firms receives different options and choices made by firms. The study this enquired the choices that firms make with regards to production decisions, as to either outsource the work, wait till light comes back, continue production used alternate power source and closing up for the day. These findings are presented in Table 4.11.

Table 4.11: Electricity outage and firms' production choices

Business Type	Run shift		Stop production		Close for the day		Continue Production		Total	
	Freq.	%	Freq.	%	Freq	%	Freq	%	Freq	%
Food processing	3	1.2%	1	0.4%	0	0.0%	38	15.5%	42	17.1%
Printing press	3	1.2%	19	7.8%	7	2.8%	35	14.3%	64	26.1%
Water Prod. Companies	0	0.0%	0	0.0%	1	0.4%	27	11.0%	28	11.4%
Soft drinks,	1	0.4%	2	0.8%	2	0.8%	40	16.3%	45	18.4%
Plastics	1	0.4%	0	0.0%	0	0.0%	15	6.1%	16	6.5%
Welders, sliding door	1	0.4%	10	4.1%	3	1.2	24	9.8%	38	15.5%
Others	0	0.0%	4	1.6%	2	0.8%	6	2.4%	12	4.9%
Total	9	3.7%	36	14.7%	15	6.1%	185	75.5%	245	100.0%

Pearson chi2 (24) = 55.6664 Prob> (Chi2) = 0.0000

Allcott et. al, (2014) found that, electricity outages affect firm's choice and productivity. According to him, firms respond to electricity outages by either self-generation or by shutting down. From the Table 4.11 above, whereas few (14.7%) of firms stop production owing to power outage, majority (75.5%) of firms still continue with production when there are power outages due to the use of other alternative sources of energy. Amadu et. al, (2016) found that, machines and labour remain idle when there are electricity outages, hence stopping production.

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Also, about 6.1% of the firms close for the day and 3.7% run shift (operate at night) when there are power outages. Out of the 75.5% firms that continue with production when there are power outages, more were in soft drinks and beverages production making a proportion (16.3%), food processing (15.5%) and printing press (14.3%) whiles the others were generally less than 10%. Also, out of the (14.7%) that stop with production when there are power outages, printing press (7.8%) contributes the greatest share followed by welders and producers of sliding doors (4.1%). Since the probability value of the chi-squared statistic, which is 0.000, is less than 5% critical error, we reject H_0, and hence there is a significant difference between the distribution. The frequent rate of power outages can adversely affect firms profit performance as certain losses arises due to the power outages. The study enquired from firms if they did experience any loss as a result of these power outages, with the results shown in Table 4.12.

Table 4.12: Losses Due to Electricity Outages

Incurred loss	**Freq.**	**Percent**
Yes	261	93.55
No	18	6.45

Uninformed power outages are argued by Allcott et. al., (2014) to affects firms' performance as it causes decreased output, revenues and raising costs. From the table 4.12 above, majority of the firms (93.55%) experience production losses, while just 6.45% firms do not experience production losses during electricity outages. The detail of these losses is explained in Table 4.13.

Table 4.13: Kind of loss incurred due to electricity outages

Variable	**YES**		**NO**	
	Freq.	**%**	**Freq.**	**%**
Raw Material Loss	21	7.34%	265	92.66%
Faulty Machinery	75	26.22%	211	73.78%
Reduced Output/Sales	248	86.71%	38	13.29%
Losing Customers	103	36.14%	182	63.86%

Due to the nature of power outages that occur during firms' operation without they are being preinformed, affect firms adversely. From Table 4.13, majority (86.71%) of the firms attributed reduced sales as a result of power outages, followed by loss of customers (36.14%) and machines developing faults (26.22%). The study therefore probed into the losses incurred by firms with regards to sales loss and machine repairs arising from these power outages. The findings on cost incurred in repairing machinery due to faults arising from power outages and sales loss incurred due to power outages in shown in Table 4.14 and Table 4.15 respectively.

Table 4.14: Cost of repairing damaged equipment's & machines due to power outages (in GH¢)

Variable	**Observation**	**Mean**	**Min**	**Max**
Cost of repairing damaged machinery	224	569.4866	15	7000

Table 4.14, reports that, the maximum cost incurred in repairing damaged machinery was about GH¢7000 and the least was GH¢15.

Table 4.15: Average monthly sales during constant electricity supply & sales loss incurred due to power outages

Business Type	Average Sales Made when there is constant electricity Supply (in GH₵)			Average Sales Loss incurred due to power outages (in GH₵)		
	Mean	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
Food processing	181,595.5	2,500	900,000	3,597.73	200	50,000
Printing press	2,706.543	80	120,000	430	30	10,000
Water Producing Companies	209,172.4	2,000	1,000,000	9,003.448	400	50,000
Soft drinks, Beverages and snacks	136,196	1,000	800,000	4,854.125	200	150,000
Plastics	20,412.5	500	300,000	785	100	2,000
Welders, sliding	11,765.31	500	200,000	2,263.26	90	50,000
Others	5,866.67	1,000	30,000	773.33	100	5,000

Pearson's correlation coefficient= 0.0321

As found by Amadu et al., (2016) loss in sales is experienced by firms when there is power outage. Amadu et al found out that the loss in income experienced by the firms due to power outages ranges between GH₵ 2 million and whooping GH₵ 9 billion. From Table 4.15 above, Water producing companies recorded the highest average monthly sales of GH¢1,000,000 with mean monthly sales of GH¢209,172.4 and a minimum of GH¢2,000 during constant electricity supply, whereas those involved in other forms of business (such as shoe making factory and sanitary product manufacturing firms) recorded the least average monthly sales of GH¢30,000 with mean monthly sales of GH¢5,866 and a minimum of GH¢1,000.

According to Allcott et. al., (2014), electricity outages cause firms physical output to drop, leading to a fall in productivity and hence loss in sales made. From Table 4.15 above, during power outage, soft drink producing companies recorded the highest average monthly sales loss of GH¢150,000 and a minimum loss of GH¢200. On the other hand, Plastic producing companies made the least loss of GH¢2,000 and a minimum loss of GH¢100. The correlation coefficient of 0.0321 shows a positive relationship between frequency of outages and the loss incurred during power outages. Thus, the loss incurred increases when the frequency of outages increases and also the loss decreases when the frequency of outages falls

Table 4.16: Alternative Source of Electricity Cost More than Direct Electricity

Does Alternative source of electricity cost more than direct electricity	Freq.	%
Yes	264	94.6
No	15	5.4
Total	279	100

Table 4.17: Firms Readiness to Pay for Uninterrupted Supply of Electricity

	Willingness to pay for uninterrupted supply of electricity											
	1% increase		2% increase		3% increase		4% increase		5% increase		Total	
Business Food	freq	%	freq	%	freq	%	freq	%	Freq	%	freq	%

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processing	11	3.9%	9	3.2%	8	2.9%	11	3.9%	3	1.1%	42	15.1%
Printing press Water producing	56	20.1%	12	4.3%	4	1.4%	4	1.4%	2	0.7%	78	28.0%
Companies Soft drinks,	8	2.9%	6	2.2%	6	2.2%	5	1.8%	3	1.1%	28	10.0%
Beverages	9	3.2%	21	7.5%	6	2.2%	8	2.9%	3	1.1%	47	16.8%
Plastics Welders,	9	3.2%	7	2.5%	1	0.4%	3	1.1%	0	0.0%	20	7.2%
sliding door	16	5.7%	16	5.7%	5	1.8%	9	3.2%	3	1.1%	49	17.6%
Others	2	0.7%	5	1.8%	3	1.1%	2	0.7%	3	1.1%	15	5.4%
Total	111	39.8%	76	27.2%	33	11.8%	42	15.1%	17	6.1%	279	100.0%

Pearson chi2(24) = 69.2997   Pr = 0.000

From Table 4.16, majority of the firms (94.6%) stated that alternative sources of electricity cost more than direct electricity thus most firms were willing to pay an extra amount to enjoy uninterrupted power supply. Firms were asked how much they were willing to pay or the extra amount that they were willing to pay to avoid electricity blackouts. Since electricity utility tariffs are not uniform but are priced following a set watt-unit bracket pricing, firms were asked if they were willing to pay a 1%, 2%, 3%, 4% and 5% increase in electricity utility tariff. From Table 4.17 directly above, majority of firms (39.8%) were willing to pay just 1% extra to enjoy uninterrupted power supply, (27.2%) were willing to pay 2% extra, (11.8%) were willing to pay 3% extra, (15.1%) were willing to pay 4% and just a few (6.1%). Since the probability value of the chisquared statistic, which is 0.000, is less than 5% critical error, we reject H_0, and hence there is a significant difference between the distribution.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study examined the effects of electricity outages on firm choices The findings revealed that majority of the firms chose to continue production during power outages. To continue production, these firms resort to the use of other alternate sources of electricity such as generators and plant, outsourcing and the use of solar. From our findings, majority of firms make use of generators and plants during outages, although they come with high operational cost.

The use of the above alternate source of electricity was found to be expensive as it increases the production cost of firms. The study found that majority of firms on monthly average, spend between GH¢15,000 and GH¢10,000 to run their alternative power supply. The study further revealed that costs are incurred by firms when they spend money in the repair of machines and equipment that get damaged due to electricity outages. Our results show that the maximum amount incurred by firms in repairing damaged equipment and machines was GHc7000 with the minimum being GHc15.

From our study, electricity outages affect firms' performance which was assessed by the monetary value of the sales they make. When there is constant electricity supply, the maximum average monthly sales made was GHC1,000,000 and the minimum average monthly sales made was GHC80.00 When there is significant occurrence of electricity outages, the maximum average sales made reduced to GHC150,000 with a minimum average sale made reducing to as low as GHC30.00. In summary, electricity outages raise cost of production and reduces sales performance of these firms. The impact of electricity outages on firms was an increase in the cost of production and reduction in the sales made by firms. Therefore, in the quest for uninterrupted electricity supply, majority of firms were willing to pay 1% increase in electricity tariff while few firms were willing to pay 5% increase in electricity tariff.

The study concludes electricity have a significant adverse impact on productivity and profitability, increasing the cost of production and reducing productivity. Aside the national gride, alternate sources of electricity for firms in Ghana is mostly fuel powered generators and plants. These sources are not sustainable as they increase firms' cost of production which consequently reduces output and sales revenue. These fuel-powered energy sources also pose higher environmental and health risks. The study argues for rethinking investment in solar energy as it offers more cost-effective, readily a viable and environmentally friendly energy sources that can drive long term production and profitability of firms in low-income economies.

Recommendation

The study found power outages to increase production cost and reduces firms' sales, putting firms in a disadvantaged position and is detrimental to firms' productivity. To avoid such disadvantage, firms were willing to pay an extra increase in tariff rates since such tariff increase is significantly less than the cost incurred in using alternate electricity sources, not forgetting the machine fault repairs. Therefore, the study recommends for the need for firms in Grater Kumasi area to diversify their power sources through investing into solar energy. This offers more cost-effective, clean and readily available energy sources. Given the huge overhead cost associated with such project, the firms in the Greater Kumasi area can pool resources together to established, own operative and share one big solar plant. This will eliminate the over- reliance on the national grid, while providing a more reliable, cheaper and readily available and sustainable energy source to drive the firms' productivity and revenues, while contributing to clean energy for sustainable community futures**.**

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