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ASSESSMENT OF IMPACT OF OUTAGES IN SELECTED ELECTRICITY INTENSIVE INDUSTRIES IN NIGERIA

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ABSTRACT

The typical Nigerian firm incurs huge costs arising from frequent cuts in electricity supply. This paper investigated the impact of power outages in Nigeria's industries for the year 2014 through the simulation of statistical data collected from two hundred and fifty (250) electricity intensive industries drawn from the nation's three major industrial cities using the Statistical Package for the Social Sciences (SPSS) Version 16.0. This study found that in 2014 alone, Nigeria's industries spent a whooping ₦2, 558,562,894,261.7equivalent to 2.26 % of the nation's GDP for that year or 56.9% of the national budget for 2015 as a result of power outages. The results further showed that Nigeria's industries suffer low capacity utilization, significant reduction in productivity, low marginal profit and lack of competitiveness in the international market due to perennial shortages in energy supply resulting from high distribution losses. The paper suggested remedial measures to mitigate losses arising from unannounced electricity cuts as well as achieve more efficient power supply to the nation's industrial sector.The findings of this research provide a data bank for industry operators, future researchers in the areas of electricity distribution as well as power sector stakeholders.

KEYWORDS: ElectricitySupply Failures,Impact of Outages,Nigeria Firms,Power Outages, Power Outage Costs

INTRODUCTION

Power outage is a major factor militating against the growth of industries in Nigeria. Despite government effort at reforming the power sector as evidenced by the unbundling of the sector in November 2013, Nigeria's industries have continued to face acute shortages of energy from the national grid forcing many to resort to the use of self-electricity generating plants which further increases the operational costs andreduces the profit margins.

Ref. [1] used the production function approach to study power outage costs in the industrial and commercial sectors in Nigeria during 1965 and 1966. The problem with this study is that the author used aggregated data for the manufacturing sector and thus omitted subsector effects of the power outages. Besides, the study focused only on output loss for unsupplied electricity and ignored other equally vital costs such as raw material and equipment spoilage and the cost of auto-generation [2].

Ref. [3] adopted the self-assessment technique to study the cost of power outages on the household sector and focused on the high-income areas of Lagos state in Nigeria namely Lagos Island, Ikoyi, Victoria Island, Yaba and Surulereand ended up with high cost estimates having concentrated his study only on the high-income subsector of the household sector in Lagos.

Ref. [4] used the self-assessment survey to measure the adaptive costs to the business sectors in coping with

infrastructural deficiencies in Nigeria. Their study found that most firms in Nigeria adapt to the unreliability of publicly provided electricity by investing in backup facilities. The problem with this study is the self-assessment approach used which suffers from the limitation of subjectivity.

Later, ref. [5] considered the different types of outage costs e.g. material and equipment loss, value of unproduced output lost, etc. through a survey of various sectors covering the industrial and commercial firms in Lagos state. However, this author like ref. [4] adopted the self-assessment survey approach widely known for subjectivity and possible exaggeration of figures by the respondents. Besides, the study was conducted within the Lagos metropolis only, thereby making generalisation of the results to other industrial areas of the country impossible.

Ref. [6] estimated the adaptive costs of electricity failure on the Nigerian economy without due consideration of the short-term losses such as raw material and equipment spoilage and lost output incurred by consumers [2]. Their research was therefore not sufficiently comprehensive and generalizable.

Lastly, ref. [2] adopted both the revealed preference approach [7,8,9] which allowed him to freely estimate the firms' willingness to pay for a reliable supply of electricity and the production approach which enable him estimate the potential losses to the firm from power outages. A major drawback of his study is that it focussed on firms located along Lagos–Ibadan, Kano–Kaduna and Anambra–Imo axes [2] thereby capturing but marginally the industrial nerve-centres of the nation. The outcome of the study can therefore be hardly generalised to other parts of Nigeria.

Unlike previous attempts to evaluate costs of outages in Nigeria, however, the current study covered Lagos, Kano and Port Harcourt which are the three most industrialised [10] and among the most populous cities in the country. The work adopted the direct assessment and the captive costs assessment methodology[11] in estimating the economic costs of the power outages among Nigerian industries – an approach different than any previously used by any study known to the present researchers. The approach is unique in that it enables the researcher to ascertain both the direct cost of power outages to the respective industries and the costs incurred by each industry as it invests in backup facilities to mitigate power outages thus checking against either overestimation orunderestimation of the actual economic costs.

With stratified sampling design employed in the work, also, it is possible to generalise the outcome of the research to all subsectors of industries in Nigeria irrespective of their individual size, business specialty and location.

METHODOLOGY

The paper adopted the stratified random sampling technique in determining the sample for the study in order to obtain the highest degree of representativeness of all the industrial strata in the population. First, the industries were stratified into size: Small-scale, Medium-scale and Large-scale. For the purposes of this research and in accordance with the National Council on Industry of Nigeria classification of 1996, industries employing less than 36 workers were classified as small-scale. Those employing between 36 and 100 were classified as medium-scale while industries having workforce above 100 were large-scale. Next, the industries were stratified according to the activities involved: Food, Beverages and tobacco, Textiles and Leather, Rubber and Chemicals, Paper and products, Metals and Products, Banking, Information and Communication Technology, etc. as these are the electricity-intensive industries in Nigeria. The industries were further stratified into manufacturing, construction and services.

Data on power outages detailing costs of production downtime, material damaged etc. as well as costs of

purchasing, running and maintaining private power generating plants and back up facilities were collected from electricity-intensive industries sampled from the Nigerian states of Lagos, Kano and Rivers by means of a well-formatted questionnaire. A total of 350 industries drawn from these three states were served with copies of the questionnaire. However, two hundred and fifty (250) copies representing 71.43 % of the total number of copies distributed were successfully retrieved. Data and information collected from these 250 respondents were thus used in this study. Analysis of the data and information so gathered was performed using the Statistical Package for the Social Sciences (SPSS) version 16.0 software (Figure 1) in order to assess the full impact of power outages on the industries concerned.The SPSS is considered most appropriate for the statistical analysis of the data owing to its versatility and in view of the large volume of data involved.

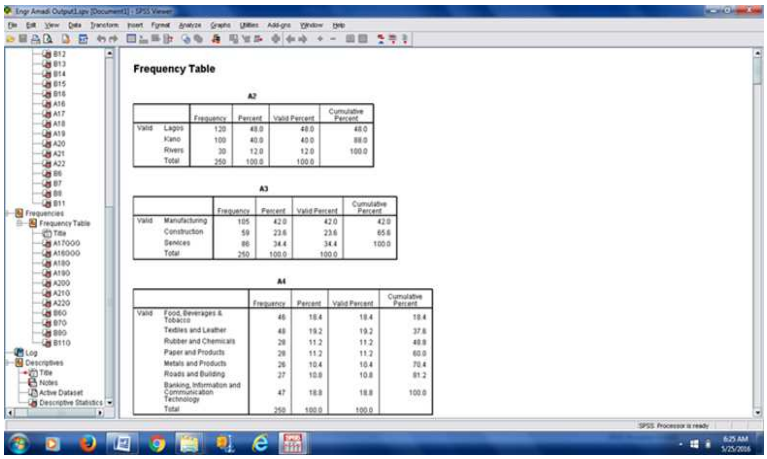

Figure 1: The SPSS Output Environment

The mathematical model for the total direct cost of power outages incurred by each of the industries selected for study can be derived as follows[11]:

$$T_{dc} = C_{dm} + C_{po} + C_{lb} + C_{de} + C_{er} + C_{rs} \quad \textbf{(1)}$$

The summation of the total direct cost for all the industries gives:

$$\sum_{i=1}^{N} T_{dci} = \sum_{i=1}^{N} C_{dmi} + C_{poi} + C_{lbi} + C_{dei} + C_{eri} + C_{rsi} + ... + C_{dmN} + C_{poN} + C_{lbN} + C_{deN} + C_{erN} + C_{rsN} \quad \textbf{(2)}$$

Where,

T_{dc} = Total direct cost incurred by each industrial consumer

C_{dm} = Cost of damaged materials

C_{po} = Cost of production output lost

C_{lb} = Cost of labour lost

C_{de} = Cost of damaged equipment

C_{er} = Cost of equipment repair

C_{rs} = Cost of restart

N = Total number of industries selected for the study

The cost per unit of electricity in Kilowatt-hour lost (₦/KwH) is expressed as:

$$C_{el} = T_{dc} / E_{ls} \quad \textbf{(3)}$$

Where,

E_{ls} = Total units of electricity, in Kilowatt-hour, lost due to power outages

In the second model designed for the total captive (indirect) cost derived from the cost of backup facilities put in place by each of the industrial consumer to mitigate power outage, we express the total captive cost or cost of backup facilities for each industry mathematically as:

$$T_{bc} = [(C_{bc} \times D_{fb}) + C_{bm} + C_{fc}] / E_{bp} \quad \textbf{(4)}$$

Consequently, the summation of the total captive cost for all the industries gives:

$$\sum_{i=1}^{N} T_{bci} = \sum_{i=1}^{N} [(C_{bci} \times D_{fbi}) + C_{bmi} + C_{fci}] / E_{bpi} + \ldots +$$

$$[(C_{bcN} \times D_{fbN}) + C_{bmN} + C_{fcN}] / E_{bpN} \quad \textbf{(5)}$$

Where,

C_{bc} = Purchase or capital cost of backup plant

D_{fb} = Depreciation factor of backup plant (assumed per annum)

C_{bm} = Annual maintenance cost of backup plant

C_{fc} = Annual cost of fueling backup plant

N = Total number of industries selected for the study

₦ = Naira

E_{bp} = Total units of electrical energy, in Kilowatt-hour, generated by backup plant per annum. Adding (2) and (5) yields:

Total cost in ₦ due to power outages,

$$T_{cpoi} = \sum_{i=1}^{N} T_{dci} + \sum_{i=1}^{N} T_{bci} \quad (6)$$

RESULTS AND DISCUSSIONS

Power Outages and Industrial Activities

The study ascertained the operational period and work hours of the industries surveyed. Table 1 shows that most of the industries represented by 65.6 % of the total number surveyed operated 24 hours a day, 6 days a week. This long work period among the industries thus accounted for the severe impact of power outages on their operations.

Table 1: Firm's Normal Hours of Operation

Hours of Operation	Frequency	Percent	Valid Percent	Cumulative Percent
8 hours a day, 5 days a week	15	6.0	6.0	6.0
8 hours a day, 7 days a week	19	7.6	7.6	13.6
12 hours a day, 5 days a week	22	8.8	8.8	22.4
24 hours a day, 6 days a week	164	65.6	65.6	88.0
24 hours a day, 7 days a week	30	12.0	12.0	100.0
Total	**250**	**100.0**	**100.0**	

Adequate and stable electricity supply is required to power and sustain the production machinery and equipment in use in the industries throughout the work period. This study observed that in line with the findings in ref. [2], the non-availability of electricity has severe adverse effect on the activities of industries operating in Nigeria.

Average Duration of Power Outages

Table 2 shows the average duration and severity of power outages among Nigerian industries.As can be seen in the Table, majority (58.8 %) of the respondents reported that most times outages last longer than 8 hours thereby crippling production activities and grossly affecting their production output and profits.

Table 2: Average Duration of Power Outages

Average Duration	Frequency	Percent	Valid Percent	Cumulative Percent
1-2 hours	10	4.0	4.0	4.0
3-4 hours	11	4.4	4.4	8.4
5-6 hours	30	12.0	12.0	20.4
7-8 hours	52	20.8	20.8	41.2
8+ hours	147	58.8	58.8	100.0
Total	**250**	**100.0**	**100.0**	

This result corresponds to the finding by ref. [12] that an average firm in Nigeria experiences an outage of 8.2 hours in a typical month. In other words, an average firm in Nigeria suffers a loss of economic activities for 216 hours (9 days), on average, monthly in the absence of backup facilities. This is in contrast to power outages of less than 15 hours a month which an average firm in East Asia & Pacific experiences.Meanwhile, a typical firm in Latin America & Caribbean

only suffers electricity supply interruptions of about 6 hours monthly [12].

Frequency of Weekly Power Outages

As can be seen in the Table 3, only 15 respondents representing 6.0 % of the 250 surveyed reported power outage frequency of 1-2 times in a week. Others claimed higher number of outages with 160 firms representing 64.0 % reporting incidents of power outages of more than 7 times per week.This represented an average of more thanone outage incidence per day and lends credence to claim by ref. [2] that Nigerian firms experienced 5 to 10 outages in a week.

Table 3: Frequency of Weekly Power Outages

Frequency of Weekly Power Outages	Frequency	Percent	Valid Percent	Cumulative Percent
1-2 times	15	6.0	6.0	6.0
3-4 times	18	7.2	7.2	13.2
5-6 times	19	7.6	7.6	20.8
7 times	38	15.2	15.2	36.0
7+ times	160	64.0	64.0	100.0
Total	**250**	**100.0**	**100.0**	

In fact, personal interview carried out in the course of the research among the industry representatives revealed that some of the industries experience as much as 20 outages in a week. This finding confirms the deplorable state of electricity supply among industries in Nigeria.

On Pre-notice of Power Outages

According to the Figure 2, two hundred and twelve (212) respondents or 84.8 % of the total respondents to the questionnaire claimed they never had pre-knowledge of power outages. Only 38 respondents or 15.2 % of the total respondents admitted receiving pre-notice of power outages during the period under review. This finding confirms an earlier claim by ref. [2] that the typical Nigerian firm experiences power failure without the benefit of prior warning. It is possible that the losses would have been minimised were the firms given prior notice on some of the outages.

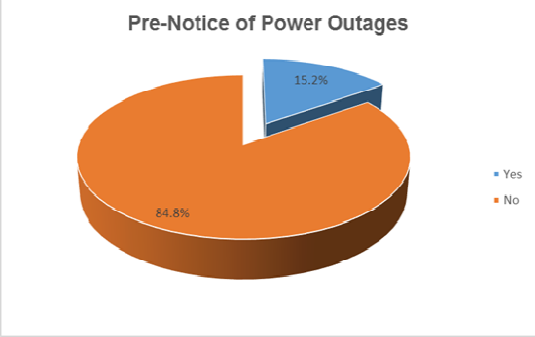

Figure 2: Pre-notice of Power Outages

Percentage of Output Reduction Due to Power Outages

As represented in Table 4, about thirty-one percent (31.14 %) of the respondents reported between 51 and 99 % output loss, 35.71 % suffered between 31 and 50 % output loss, 20 % reported 11-30 % output loss, 8.57 % reported less than 10 % output while 1.71 % reported no loss arising from power outages. This result shows that majority of Nigerian

firms experience production output reduction in the range 31-50 % due to power outages.

Table 4: Percentage of Output Reduction Due to Power Outages

Percentage of Output Lost	Frequency	Percent	Valid Percent	Cumulative Percent
0	5	1.71	1.71	1.71
Less than 10	25	8.57	8.57	10.28
11-30	50	20	20	31.99
31-50	90	35.71	35.71	67.7
51-99	80	31.14	31.14	
Total	**250**	**100.0**	**100.0**	

Perceived Effect of Power Outage on Production Output

The respondents were asked to report on the effect of power outages on the production output of their respective firms. Only 16.4 % reported no effect of power outages on their production output. The majority of the respondents (83.6 %) said that power outages had severe negative impact on their production output levels. Figure 3 shows the perceived effect of power outages on production output as reported by the respondents.

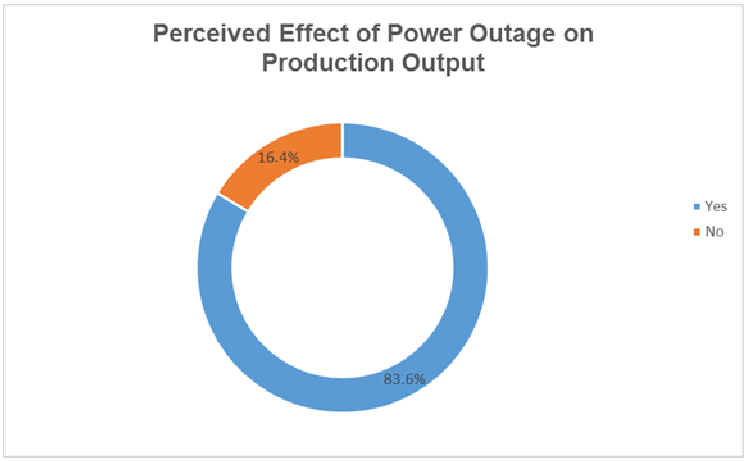

Figure 3: Effect of Power Outage on Production Output

Power outages lead to sharp decreases in the productivity of industriesand increases the loss of capacity utilization thereby compelling firms to cut down on the sizes of their workforce thus worsening the unemployment situation.The study thus found that power outages have diverse impact on industries. This finding confirms the earlier claim by ref [13] that the increasing rate of unemployment in Nigeria is attributable to inadequate and unreliable power supply to the nation's industrial sector. This study further reveals that absence of adequate electricity supply dwindles firms' sales volume and consequent profits**.** Power cuts make business investors to dilly-dally and even withdraw totally, thus the economy ails and the national currency is weakened. This finding confirms the opinion of ref. [14] that power outages cripple industrial activities.

Power outages affect the competitiveness of manufacturing firms by resulting in high cost of finished goods owing to additional costs which firms incur due to these outages. Epileptic power supply also compels firms especially the small-scale firms to adopt manual methods which reduce product quality, or sometimes result to halted production and delay order delivery.

Percentage of Production Output That Gets Reduced by Power Outage Monthly

Table 5 shows the percentage of production output that gets reduced due to the occurrence of power outages monthly. As can be seen from Table 5, four percent (4%) of the respondents reported losing between 0 and 10% of their production output to power outages monthly. About 5 % of the total respondents reported losing all their products each time power outage occurred while 6.4 % of the respondents said power outages caused 51-70 % reduction in their production output. Meanwhile, about 7 % of the population surveyed announced between 71 and 99% reduction in production output caused by power outages while 9 % of the respondents reported losing between 31 and 50% of their production output to electricity supply cuts. The majority (69.6 %) of the respondents said they lost between 11 and 30 % of production output to power outages monthly.

Table 5: Percentage of Production Output That Gets Reduced by Power Outage Monthly

Percentage Average	Frequency	Percent	Valid Percent	Cumulative Percent
Between 0-10%	10	4.0	4.4	4.0
Between 11-30%	174	69.6	69.6	73.6
Between 31-50%	22	8.8	8.8	82.4
Between 51-70%	16	6.4	6.4	88.8
Between 71-99%	17	6.8	6.8	95.6
100% Loss	11	4.4	4.4	100.0
Total	**250**	**100.0**	**100.0**	

Percentage of Annual Sales Lost due to Power Outages

According to Table 6, 11.6 % of the industries surveyed reported losing between 1 and 5 % of their annual sales to power outages. This is besides 14.4 % that claimed loss of between 6 and 10 % of annual sales. Another 10.4 % disclosed that their firms suffered loss in annual sales between the range of 11 and 15 %. Yet another 14.8 % of the respondents reported no loss at all in annual sales. The no loss in sales report by these firms is attributable to the fact that they had some arrangement with the public utility for a more dedicated electricity supply and therefore had electricity available for them most of the time. However, majority (48.8 %) of the firms investigated reported much losses in their annual sales volume in the range of 16 and 20 %.

Table 6: Percentage of Annual Sales Lost due to Power Outages

Perceived Sales Lost	Frequency	Percent	Valid Percent	Cumulative Percent
Between 1-5%	29	11.6	11.6	11.6
Between 6-10%	36	14.4	14.4	26.0
Between 11-15%	26	10.4	10.4	36.4
Between 16-20%	122	48.8	48.8	85.2
No loss	37	14.8	14.8	100.0
Total	**250**	**100.0**	**100.0**	

Ranking of Severity of Service Problems to Firm's Operation (in Percentage)

Table 7 shows that majority of the surveyed firms represented by 92.0 % of the population reported power outages as the most significant obstacle to their daily operations. This finding confirms the fact that power outages pose serious obstacle to the activities of industries in Nigeria and lends credence to an earlier investigation by ref. [2].

Table 7: Ranking of Severity of Service Problems to Firm's Operation (in Percentage)

Infrastructure	Major Obstacle	Moderate Obstacle	No Obstacle
Land	33.4	24.3	42.3
Petroleum shortages	49.4	28.3	22.3
Water	26.3	40.5	33.2
Electricity	92.0	7.2	0.8
Road	35.7	25.5	38.8
Telecommunication	24.8	52.6	22.6

Direct Costs due to Power Outages in Firms

As shown in Table 8, direct costs incurred by each of firms due to power outages included restart, damage to materials, production output, equipment damaged and labour lost. The summation of these costs as derived from each firm thus yielded the total direct cost (₦387, 371,367,093.7) incurred by all the industrial firms surveyed.

Table 8: Direct Cost Incurred by Firms

Cost Type	Amount (₦)	Percentage of Total Cost
Restart costs	9,684,284,177.35	2.5
Damaged materials	32,926,566,202.9	8.5
Production output lost	309,897,093,675	80.0
Damaged equipment	25,179,138,861.1	6.5
Labour lost	9,684,284,177.35	2.5
Total Cost	**387,371,367,093.7**	**100**

Indirect Costs due to Power Outages in Firms

As represented in Table 9, the total indirect cost incurred by the firms was ₦2, 171,191,527,168. This amount added to the total direct cost of ₦387, 371,367,093.7 obtained in Table 9 yielded total outage cost of ₦2, 558,562,894,261.7 among the Nigerian industries. It is possible that this outage cost would have been higher but for the mitigation measures adopted by the individual firms through adequate investment in self-generation facilities.

Table 9: Indirect Cost Incurred by Firms

Cost Type	Amount (₦)	Percentage of Total Cost
Generator	68,609,652,258.509	3.16
Maintenance	20,409,200,355.379	0.94
Fuel	2,082,172,674,554.1	95.9
Total Cost	**2,171,191,527,168**	**100**

Firm's Perception of Factors Hindering Efficient Performance of the Nigeria Power Sector

The industrial sector is supposed to be a significant contributor to the nation's gross domestic product (GDP). But this has not been the case. A review of literature revealed the following fundamental problems which confront the sector but which hitherto have either not been addressed at all or have not been holistically tackled. These include inadequate, inefficient, and dilapidated infrastructural facilities namely electricity road, water, transportation, communication, etc. which tend to escalate costs of operation as the industries resort to private provisioning. The respondents to the study attributed the power outages in the Nigerian industries to several factors as represented in the Table 10.

Table 10: Firm's Perception of Factors Hindering Efficient Performance of the Nigeria Power Sector

Causative Factors	Percentage Perception	Ranking
High transmission and distribution losses	87.6	3
Vandalism/Sabotage	54.8	6
Corruption	97.1	1
Under-funding/lack of investment	38.9	8
Low tariff and poor collection efficiency	72.4	4
Tariff debts by Consumers	40.2	7
Inadequate electricity infrastructural facilities	30.7	9
Gross neglect by successive governments	63.7	5
Dilapidated transmission/distribution networks	25.5	10
Bad Leadership	95.9	2

The factors include corruption, gross neglect of the power sector by successive governments, high transmission and distribution losses, low tariff and power collection efficiency, managerial inefficiency etc.

The respondents were asked what they considered the major reason for the poor performance of the nation's electric power sector. The study outcome as depicted in Table 10 reveals that the bane of the poor performance of Nigeria's electricity sector is basically corruption (97.1%). This is followed by bad leadership (95.9%) characterised by policy somersaults and tolerance of corrupt practices among public officials etc. This finding agrees with ref. [2] which summarised corruption as the principal reason behind the unsatisfactory performance of the nation's power sector.

Percentage of Industries that own Backup Generators

As can be seen from Table 11, a whooping percentage (99.2 %) of the firms surveyed owned one or more units of back-up generators. This finding shows the unreliability of electricity supply from the grid and confirms the belief amongst most business owners in Nigeria that the only way to militate against operational losses resulting from incessant power outages is by owning private electricity generators.

Table 11: Percentage of Industries that Own Backup Generators

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	248	99.2	99.2	99.2
No	2	0.8	0.8	100.0
Total	**250**	**100.0**	**100.0**	

However this finding (99.2%) reveals that there is a slight increase in the value (97.7 %) earlier declared by ref. [15]. This is an indication that an increasing number of firms in Nigeria are resorting to private electricity generation to mitigate effect of power outages.

Alternative Measures Adopted By Firm to Mitigate Power Outages

The study findings shown in the Table 12 revealed that 72.4% of the firms adopted backup generators as alternative measure to mitigate power outages. This is while 17.2% of the firms chose use of overtime as a strategy to make up for lost hours arising from power outages. About 7% adopted working additional shifts to compensate for the effects of power outages while 3.6% chose making more intensive use of available machinery to mitigate power outages in their firms.

Table 12: Alternative Measures Adopted By Firm to Mitigate Power Outages

Measures	Frequency	Percent	Valid Percent	Cumulative Percent
Backup Generator	181	72.4	72.4	72.4
Use of overtime	43	17.2	17.2	89.6
Working additional shifts	17	6.8	6.8	96.4
More intensive use of machinery	9.0	3.6	3.6	100.0
Total	**250**	**100.0**	**100.0**	

The implication of this finding is that majority of the firms prefer backup generators in making up for losses arising from sudden electricity supply interruptions from the grid.

Major Sources of Electricity used among the Industries

Most of the industries surveyed owned one or more backup generators and equipment to mitigate the effect of power outages. The results as presented in Table 13 show that only an insignificant 7.6 % of the firms studied depended on the public utility (grid) as only source of power while 10 % relied on the public utility as main power source. This is against the background that majority of the firms represented by 48 % of the total firms surveyed depended only on private sources of electricity whereas another 34.4 % relied on their private facility as major source of electricity thus lending credence to the claim by ref. [16] that most industrial firms in Nigeria utilised their private generating plants as the major source of electricity supply while the public utility served as back-up.

Table 13: Major Sources of Electricity used among the Industries

Source of Electricity	Frequency	Percent	Valid Percent	Cumulative Percent
Public utility only	19	7.6	7.6	7.6
Public utility main	25	10.0	10.0	17.6
Private source only	86	34.4	34.4	52.0
Private source main	120	48.0	48.0	100.0
Total	**250**	**100.0**	**100.0**	

Percentage of Initial Outlay invested in Back-up Generation of Electricity by Industries

The study results in Table 14 show that 43.6% of the total respondents invested 20-30% of the initial outlay in backup generators. Forty percent (40%) invested 10-20% of initial outlay in backup electricity generation while 8% invested about 10% of initial outlay in backup facilities. These results confirm earlier findings by refs. [4]and[17] that due to energy shortages, industries in Nigeria spend a large proportion of their initial outlays on backup generating facilities.

Table 14: Percentage of Initial Outlay Invested In Back-Up Generation of Electricity ByIndustries

Percentage of Initial Outlay	Frequency	Percent	Valid Percent	Cumulative Percent
0-10	20	8.0	8.0	8.0
10-20	100	40.0	40.0	48.0
20-30	109	43.6	43.6	91.6
More than 30	21	8.4	8.4	100.0
Total	**250**	**100.0**	**100.0**	

Comparison of Cost of Electricity from Self-generation and National Grid

As can be observed from Table 15, 81.6% of the total number of respondents claimed self-generated electricity was more expensive than electricity from the grid. About 11% declared that there was no difference in terms of cost between self-generated electricity and electricity from the grid. This is while about 4% reported that self-generated

electricity was cheaper than electricity from the grid. Four percent (4%) of the respondents claimed that there were no differences between the cost of self-generated electricity and electricity from the grid.

Table 15: Comparison of Cost of Electricity from Self-Generation and National Grid

Comparison	Frequency	Percent	Valid Percent	Cumulative Percent
Cheaper than National Grid Electricity	9	3.6	3.6	3.6
More expensive than National Grid Electricity	204	81.6	81.6	85.2
There is no difference	27	10.8	10.8	96.0
Not Applicable	10	4.0	4.0	100.0
Total	**250**	**100.0**	**100.0**	

The study thus found that electricity from the grid is cheaper than self-generated energy. This fact is buttressed by the findings in Table 20in which it is shown that though the public utility provided as much as 70.5 % of the total electricity consumed i.e. 20,235,885.95 ('000Kwh) by the sampled industries in 2014, the average cost of electricity consumed was only ₦428,524,643,700 at average cost per KWh of ₦30. But with the mere 29.5% of the total electricity sourced from the back-up facilities, the 250 firms surveyed spent a whooping ₦2,171,191,527,168 on self-generation at an average cost per KWh of ₦364.80 for that year. The implication is that self-generated electricity costs much more than electricity from the grid and confirms the claim by ref. [17] that self-generated electricity is generally more expensive than electricity from the public utility and therefore adds to the capital, operating and production costs of doing business thus increasing the prices of finished goods and lowering the competitiveness of local products.

On Whether Self-Generation of Electricity Increases or Decreases Production Cost

The survey result in Table 16 shows that only about 17 % of the firms argued that self-generation of electricity does not lead to increases in production cost. This is while 83.6 % of the firms surveyed admitted that self-generation of electricity increases production cost and drastically reduces the competiveness of locally manufactured products and makes them unattractive in the global arena.

Table 16: On Whether Self-Generation of Electricity Increases or Decreases Production Cost

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	209	83.6	83.6	83.6
No	41	16.4	16.4	100.0
Total	**250**	**100.0**	**100.0**	

This is in line with the claim by ref. [17] that self-generated electricity adds to the capital, operating and production costs of doing business thus lowering the competitiveness of local products and increasing the prices of finished goods.

Percentage by Which Self-Generation Increases Monthly Production Costs

From Table 17, most of the respondents (83.6 %) admitted that self-generation of electricity increases production cost while only 16.4% held a contrary opinion. The opinion of the former group confirms earlier claim by studies such as ref. [17] that self- generation of electricity results in increases in production cost. In other words, mitigation measures adopted by firms in order to mitigate the effects of power outages actually lead to increased production costs as the firms invest much funds in acquiring backup generating facilities which add up toraise drastically the overall production costs [2].

Table 17: Percentage by Which Self-Generation Increases Monthly Production Costs

Percentage Increase	Frequency	Percent	Valid Percent	Cumulative Percent
0-5	23	9.2	9.2	9.2
6-10	28	11.2	11.2	20.4
11-15	45	18.0	18.0	38.4
16-20	154	61.6	61.6	100.0
Total	**250**	**100.0**	**100.0**	

Does Power Outage Lead to Reduction in Firm's Monthly Profit?

As shown in Table 18, about 87% of the total respondents reported that power outages lead to reduction in firm's monthly profit while only about 13% claimed that power outages do not affect firm's monthly profit. This researcher found out in the course of personal interviews carried out among the respondents that the latter group depended more on private electricity generation than on energy from the grid.

Table 18: Does Power Outage Lead to Reduction in Industry's Monthly Profit?

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	218	87.2	87.2	87.2
No	32	12.8	12.8	100.0
Total	**250**	**100.0**	**100.0**	

This study revealed that monthly profits accruing to all the firms dwindle because they invest more to generate their own electricity which adds to their production expenses. Besides, power outages lead to equipment damage which sometimes affects the quality of the finished goods. The cost of this coupled with the cost of equipment repair and down time result in increased maintenance and production costs. Industries that employed mitigation measures such as standby generators and overtime against the impact of power outages, thus report negative impact on their profitability due to increased operational costs. These confirm the claim by ref. [18] that the more frequent the power outages, the lower the Return on Investment (ROI) of firms and the more the decline in the Gross Domestic Product (GDP) of the host country.

Percentage by Which Industry's Monthly Profit Is Reduced ByPower Outage

The study finding reported in Table 19 shows that 60% of the respondents reported reduction in monthly profit of 11-15% due to power outages. Nineteen percent (19%) announced reduction in monthly profit of 16-20 % while 11% claimed a reduction of 6-10% in monthly profit. About 10% reported less than 5% reduction in monthly profit resulting from power outages.

Table 19: Percentage by Which Industry's Monthly Profit is reduced by Power Outage

Percentage Reduction	Frequency	Percent	Valid Percent	Cumulative Percent
0-5	24	9.6	9.6	9.6
6-10	28	11.2	11.2	20.8
11-15	150	60.0	60.0	80.8
16-20	48	19.2	19.2	100.0
Total	**250**	**100.0**	**100.0**	

Electricity Consumption and Average Cost

Table 20 shows that the average cost of electricity consumption by the sampled industries in 2014 was ₦2,

599,716,170,868 or ₦2.6 Trillion. A breakdown of this figure shows that though the public utility provided about 70.5 % of the total electricity consumption by the industries that year, the average cost per KWh was ₦30 such that the average cost of electricity consumed was ₦428, 524,643,700 or ₦4.29 Billion. But, the electricity from the back-up facilities though only 29.5 % of the total electricity consumption by industries that year, the 250 firms surveyed still spent as much as ₦2,171,191,527,168 or ₦2.17 Trillion on self-generation at an average cost per KWh of ₦364.80. It is obvious therefore that electricity supplied from the public utility is by far cheaper than self-generated electricity.

Table 20: Electricity Consumption and Average Cost

Source	Electricity Consumption ('000Kwh)	Cost of Electricity (₦)	Average Cost (₦/Kwh)
Public Utility	14,284,154.79	428,524,643,700	30
Back-up Generator	5,951,731.16	2,171,191,527,168	364.8
Total	**20,235,885.95**	**2,599,716,170,868**	

CONCLUSIONS

This study applied both the direct costs and the captive costs assessment methods and relevant data simulated on the Statistical Package for the Social Sciences (SPSS) in evaluating the impact of power outages on the industries. The outcome of the investigation shows that energy shortages in the Nigeria's industrial sector have significant economic effect on the nations' economy. The survey carried out by this studyfound that the direct cost of power outages incurred by Nigeria's industries amounted to ₦387,371,367,093.7 while the indirect cost was ₦2,171,191,527,168. The implication of this is that in 2014 alone, Nigeria's industries spent a whooping₦2, 558,562,894,261.7 (Two Trillion, Five Hundred Fifty-eight Billion, Five Hundred Sixty-two Million, Eight Hundred Ninety-four Thousand, Two Hundred Sixty-one Naira, Seventy Kobo only equivalent to 2.26 % of the nation's GDP for that year [19] or 56.9% of the nation's budget for 2015 [20] as a result of power outages. In other words, in 2014 alone, power outages in Nigerian industries chopped off at least 2.26 % of the nation's GDP for that year. This is proof that Nigeria is among African countries that incur economic cost of power shortages to the tune of more than 2.0 % of gross domestic product. The results further show that Nigeria's industries suffer low capacity utilization, significant reduction in productivity, loss of revenue and lack of competitiveness in the international market due to perennial shortages in energy supply, etc. The study therefore makes the following recommendations towards mitigation of losses arising from unannounced electricity cuts as well as achieving more efficient power supply to the nation's industrial sector:

i. The nation's power transmission and distribution infrastructures should be urgently upgraded. The number of power generating stations should be increased also to meet the ever increasing demand for electricity while the power stations should be rehabilitated and the weak transmission lines replaced in order to further strengthen the network.

ii. Power utilities should as far as is practicable endeavor to give consumers pre-notice of power outages. This will enable electricity consumers prepare for such outages as well as guard against unnecessary losses that may otherwise result from such occurrences.

iii. Distributed generation should be considered and possibly adopted by power sector stakeholders in order to shorten the length of the existing transmission and distribution lines both of which contribute to the energy losses and outages in the power system.

iv. Dedicated Micro grid should be created for industrial consumers across the country. Such grids fed from larger distribution grids should supply electricity to industrial clusters thereby solving the perennial problem of low industrial productivity and lack of growth in national economy due to acute shortages of electricity supply to the industries.

v. Nigeria should diversify into renewable energy sources such as solar, wind, biofuels, and traditional biomass.

vi. Public Private Partnership should be encouraged to participate in the expansion and fortification of the national grid by replacing the lines having single circuits with double and triple circuits thereby making the network more efficient and reliable.

vii. Government should encourage investment in generation capacity expansion and strengthening of the sector infrastructure facilities to ensure efficient delivery of electricity to the consumers.

viii. Government should encourage rural households as well as micro- and small-scale business outfits in remote or isolated areas to use and be supplied off-grid from renewable energy sources. This would take off some loads from the grid system and make it perform more efficiently and effectively.

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COMPETING INTERESTS

The authors declare that no competing interests exist.

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