ASSESSMENT OF THE IMPACT OF POWER OUTAGES ON COMMERCIAL CONSUMERS (A CASE STUDY OF COLDROOMS CONSUMERS AT TRANS-AMADI AREA, PORT- HARCORT)

BY

IkechukwuYagazie, NKEMDIRIM

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DECLARATION

I hereby declare that this Project titled "**Assessment of The Impact Of Power Outages On Commercial Consumers(a case study of cold-rooms consumers at Trans-amadi area, Port-harcort)"** was written by me in the Department of Mechanical Engineering under the supervision of Dr. D.S. Yawas and Dr. F.O Anafi. The information derived from the literature has been duly acknowledged in the text and in the form of references provided. No part of this work has been produced for another degree or diploma at any institution.

NkemdirimIkechukwuYagazie

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Name of Student Signature Date

CERTIFICATION

This project titled; ASSESSMENT OF THE IMPACT OF POWER OUTAGES ON COMMERCIAL CONSUMERS (A CASE STUDY OF COLD-ROOMS CONSUMERS AT TRANS-AMADI AREA, PORT- HARCORT)by IkechukwuYagazie, NKEMDIRIM

meets the regulations governing the award of the degree of Masters in Engineering Management (MEM) of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr. D.S Yawas
---------- ---------- ----------
(Chairman, Supervisory Committee) Signature Date

Dr. F. O Anafi
---------- ---------- ----------
(Member, Supervisory Committee) Signature Date

Dr. M.Dauda
---------- ---------- ----------Head of Department Signature Date

Prof. A. A. Joshua
---------- ---------- ----------
Dean, School of Post Graduate Studies Signature Date

DEDICATION

This Project work is dedicated to Almighty God for His wisdom, knowledge and understanding granted to me: To the Nkemdirim Family and my three lovely Children: Oma, Ola and Chibudikem.

ACKNOWLEDGEMENT

It is my pleasure to acknowledge the various contributions made by different personalities towards the realization and completion of this project work and I am grateful to all of them. My sincere gratitude goes to my Major supervisor Dr. D.S Yawas and the Minor Supervisor Dr. F.O Anafi who also doubles as the course Coordinator of Engineering Management, for their untiring advice, encouragement and corrections throughout the period of this project work.

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ABSTRACT

The effects of electric power interruptions resulting from severe power outages were investigated and analyzed using five cold rooms as a case study. Two approaches have been developed and used. One is based on customers' survey that mainly investigates the preparatory actions that a customer may take to reduce the effect of outages. The other one is based on a mathematical model using standard deviation as a measure of dispersion. The spearman's correlation factor with the aid of visual basic program was used to X-ray the cost implication involved in running these cold rooms with the utilization of power supply from PHCN to be more economical than powering from individual power generating sets. Furthermore the regression cost analysis showed that cold room 1, cold room 2, cold room 3, cold room 4, and cold room 5 have a spearman correlation factor of 40.04%, 41.93%, 39.16%, 31.97% and 31.09% respectively, which shows how expensive the use of private power source over using PHCN, while the frequency distribution of power outages stood at a standard deviation of 3.78.

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Electric power interruptions occur when system capacity, due to severe power outages, is insufficient to meet the system load levels. During these periods of inadequacy, outage costs will be borne by the utility, its customers and perhaps, by' the entiresociety. The utility outage costs include loss of revenue, loss of future sales and increasedrepair expenditure and maintenance. These costs usually form only a smallpart of the total outages costs. The greater part is that borne by the consumers. Theoutage costs depend on many factors and situations, some of which are discussed inthe following sections. The problem of estimating outage costs is affected by the per*ceived*costs of an *electric* outage and the point in time when a consumer would like tobuy electric energy but is unable to do so. Since there are different classes ofconsumers,each will tolerate loss of service differently. A residential consumer may suffer agreat deal of hardship if an outage occurs during a hot summer day or while he is engagingin domestic activities but it may be of little inconvenience to a commercialuser who is forced to close until power is restored. Also an outage may cause a greatloss to an industrial user if it occurs during the time of the production process. Therefore,consumers do not perceive service interruption to the same degree of hardship.The outage costs to a particular consumer depend also on the alternatives availableto that individual at the time of service interruption. If the outages are not expected,the consumer may have very limited alternatives and may incur a great loss. On theother hand, if an adequate warning is given, the losses may be averted or mitigated.Also, as an outage continues or spreads to a larger subset of society, the society costwill tend to increase and will include such indirect

costs as effects of anxiety, loss ofproducts, food spoilage, health hazards, etc. The major aspect of outage costs estimation is to assess the worth of power system reliabilityin order to compare it withthe cost of power system so as to establish an appropriate system reliability level. Inthis regard, it is important to realize that, while the evaluation of power system reliabilityhas become a well established practice over the last decade, the assessment ofthe worth of reliability or conversely, the estimation of costs of losses, which resultfrom system unreliability, is still immature. The major reason for this is that quantificationof interruption costs is an intricate and often a subjective task.

1.1.1 Classification of Outages

Power outages are classified under the following headings (PHCN, 2012)

i. Forced outages
ii. Emergency outages
iii. Planned outages

i. Forced outages

These are primarily as a result of faulty situations in the network which are normally initiated by electrical sensing devices called relays. It could also be as a result of over loading in a particular branch of the network which the relay is overseeing.

ii. Emergency outages

As the name implies this type of power interruption is initiated by qualified PHCN personnel under emergency situations to avert any danger which may be as a result of temporary removal of load (load shedding) or as a result of poor generation.

iii. Planned outages

These are power interruptions which are initiated by PHCN to carry out maintenance work on their equipment or to connect new extensions to the existing ones. Similarly, in transmission stations, the bulk transformers, circuit breakers, isolators, protective and communication equipment are often time scheduled to be over hauled so as to enhance their efficiency (PHCN, 2012).

The faults that can lead to maintenance, reconstruction, or repairs to be carried out in the network are: (PHCN, 2012).

i. Changing of broken wooden cross arm involving High Tension (H.T.) lines;
ii. Vegetation on line;
iii. Changing of broken or collapsed wooden or reinforced concrete poles;
iv. Replacement of shattered disc or pot insulators, lightening arresters, and closure of J & P 'D' fuse that was ill-fitted;
v. Faulty underground cable;
vi. Mending of broken up riser cable ends
vii. Extension of H.T. overhead lines;
viii. Mending of jumper cuts, among others
ix. Construction of substations;
x. Installation of RMU and so on

Faults on High-Voltage feeder can be classified into two main groups. These are:

i. Earth fault
ii. Over current fault

Earth fault may occur as a result of the grounding of the feeders, through vegetation of disc or pin insulator on the lines.

Over-current occurs as a result of the short circuiting of the feeder by a metallic object or vegetation. Over-current can also occur as a result of over loading of the feeders such that relay setting cannot accommodate the excess load.

In summary, any power outages has the general consequences of throwing the electricity consumers into yet another long hours of electric supply stagnation which may result in both material and economic loss.

1.1.2 Classification of Damages Caused By Electrical Power System

Problems associated with electrical power system can be classified according to their causes namely:

i) Damage resulting from ulterior causes, such as the perching of birds and falling of trees. Failure may be at normal voltage.

ii) Deterioration of insulation, which is inherent in the system and as a result breakdown may be at normal voltage.

iii) Breakdown due to deterioration of insulation, which is accelerated by self generated surges following switching or other disturbances.

iv) Insulation collapsing due to direct strokes of lighting or consequent disturbances. The fault will not be normal voltage. (Okeke, 1998)

1.2 Statement of Research Problem

Electrical power disturbances have been a major constraint in our society Nigeria, as it influences our socio-economical activities. This Project work critically viewed the problems and cost associated with assessing the effects of electrical power outages on commercial consumers (cold room consumers) using electricity in Trans-Amadi area of Port Harcourt, Rivers State. Thiswork identifiedthe problems of electrical power transmission and distribution that influences electrical power outages to cold-room operators at Trans-Amadi area of Port-Harcourt.

1.3 Aim and Objectives

The aim of this project is to access the electrical power outages effect on commercial cold room operators in the Trans-Amadi area of Port-Harcourt. The specific objectives are;

i) To examine the impact of power outages on electricity demands by cold-room operators in Trans-Amadi area of Port-Harcourt.

ii) To show the frequency distribution and obtain the standard deviation of power outages for a period of three years.

iii) To show the cost of running a private generating source of power over PHCN using the spearman's correlation factor.

iv) To proffer solutions andrecommendations to resolving the power outages issues in Nigeria.

1.4 Significance of Study

Considering the Statistical model employed in the analysis of power outages within Trans-Amadi, area of Port-Harcourt, it has been discovered that the electrical power outages within the area under consideration if evenly distributed, the cost effect will be minimal on the commercial

consumers. Spearman's correlation coefficients were used in the cost analysis to compare using individual generating sets and power from the National grid.

1.5 Scope of the Study

This work examines commercial power consumption connected to the National electricity network of PHCN in Trans-Amadi area of Port-Harcourt. It analyzes the cost implication of power supply outages, using the spearman's correlation factor and the frequency of distribution of outages by a statistical model.

CHAPTER TWO

LITERATURE REVIEW

2.1 HistoricalEmergence of Power Generation and Consumption in Nigeria

The history of Electricity generation in Nigeria date back to 1896 when the first electricity generating machine was installed in Lagos; 24/25 Marina road fifteen years after its introduction in England (Joseph and Adebayo, 2012). The purpose was to supply electricity to the governor's house and government house. During this period the total of the generators used then was 60kW. Towards 1913, the electricity supply was extended to Iddo. In 1922, Ijora 'A' power station was built. The control of electricity in Lagos state was under the public works department (PWD) at this period. In 1950, the electricity corporation of Nigeria (ECN) was established through the ordinance No 15 of 1950 which merged public works department, native authorities and, municipal authority under one control (Onyekwere, 1991). Also in 1962, another body known as Niger Dams Authority (NDA) was established by an act of parliament. The Authority was responsible for the construction and maintenance of dams and other works on the River Niger and elsewhere generating electricity by means of water power, improving navigation and promoting fish brines and irrigation. The energy produced by NDA was sold to ECN for distribution and sales at utility voltages. In first April 1972, the operation of ECN and NDA were merged in a new organization known as National Electric Power Authority (NEPA) (Joseph and Adebayo, 2012). The primary reasons for merging the organizations were:

i. It would result in the vesting of the production and the distribution of electricity power supply throughout the country in one organization which will assume responsibility for the financial obligations.

ii. The integration of the ECN and NDA should result in the more effective utilization ofthe human, financial and other resources available to the electricity supply industrythroughout the country.

NEPA as a government monopoly, was plagued with inefficiency which is usually the characteristics of almost all government monopolies in the developing countries and as such, there is constant power outage and blackout all over the country; (Adenikinju; 2003). This problem led to federal government consideration of the privatization of this corporation in the year 2005. This privatized company was renamed Power Holding Company of Nigeria (PHCN) PLC and was broken into 18 independent units which included the transmitting company of Nigeria (TCN),6 generating companies and 11 distributing companies. Each of these companies is to be privatized. Despite this privatization move, the constant power outage still remains a problem to the Nigeria economy (Joseph and Adebayo, 2012)

2.2 Historical Blackout in the World

Table 2.1 below represents a summary of some major blackouts previously experienced in the world. Amongst the previous outages, only the incident in the Philippines was caused by a factor similar to the main cause of power outages in Africa. While the causes of major outages in Europe and north America had been attributed to natural disasters or technical faults, the massive blackouts in the Philippines (1992-1994) was caused by inadequate generating capacity. The inadequate capacity brought by poor implementation of energy planning and obsolete power

plants resulted in daily average duration of 12 hours outage time. This resulted in economic loss ranging from US$600million-US$800million yearly average (Warwick and Diog, 2004).

Like that of the Philippines, the major cause of power outages in Africa is inadequate installed and generating capacity which resulted from poor planning and implementation. Due to inadequate installed capacity, electricity generation is always low and subsequently causes supply to fall below demand. Inadequate generation results in low power supply and constant blackouts. The continent's generating capacity is the lowest amongst the regions in the world and in many cases is less than the installed capacity in some countries. Africa accounts for only 2.65% of the world generating capacity in 2008. Out of this total capacity, South Africa alone contributed about 36%. At 122.6 gigawatts (GW), the entire generating capacity in the continent is less than that of India. Excluding South Africa, the total generating capacity is less than 80 GW, and is about 5GW short of the installed capacity in Spain. Moreover, more than 40% of this installed capacity is not currently generated due to poor maintenance and sometimes vandalisms of equipments.

Table 2.1: Historical Blackouts in the World

Country, Year	Type of Incident	Consequences in The Power System	Social Consequences		
			Number of end-users Interrupted	Stip. Duration, energy not supplied	Estimated Costs To Whole Society in 2010 Prices
Sweden/ Denmark 2003	Disconnector short circuit followed by double busbar short circuit	Loss of all lines and generation separation of Southern Sweden/Denmark Voltage collapse	1.6 million in Sweden and 2.4 million in Denmark	2.1 hours, 18 GWh	(US$ 206.22-256 million)
France, 1999	Two consecutive Syorms, extreme wind.	Extensive outages, 0.4% of the total network length damaged	1.4-3.5 million	2 days- 2 weeks, 400 GWh	(US$ 14.13 billion)
Italy/ Switzerland 2003	Overloading lines between Switzerland and Italy	Collapse of the entire Italian electric power system	55 million	18 hours	n.a
Sweden, 2005	Storm Gudrum, extreme wind	Extensive damage of overhead lines in Southern Sweden	0.7 million	1 day – 5 weeks, 111 GWh	(US$ 526 million)
Central Europe 2006	Busbar fault at a substation in Germany	Disturbances in the whole interconnected grid in Europe	15 million households	Less than 2 hours	n.a
London, 2003	Poor Protection Relays	Disturbances of 720 MW in South London	410,000 people	37 minutes	n.a
Philippine, 1992- 1994	Insufficient generation capacity	Interruption in Country wide electricity supply	Entire country	12 hours daily	US$ 1.89 -2.52 billion per annum
US/ Canada, 2003	Tree flashovers	Disturbances in interconnector grid in North America	50 million people	16 hour – 1 week	US$ 8.3 - $ 11.9 billion

Source: (Bialek, 2004; US-Canada Power System Outage Task Force 2003, 2004)

2.3 Effect of Power Failure on Households

Power failure impact on the households in various ways. Its impact varies from the experience of dark night to a lot of damages being caused to household requirements. Many households have their fridges, television sets, video sets and a host of household equipments damaged due to frequent power failure. Also, what the households would have purchased in bulk (perishable goods) and kept in refrigerators is bought in bits. According to Agenor and Moreno- Dodson (2006), studies have shown that infrastructure like improvement in road transport, electricity and sanitation as well as better communications has led to more enrolment and better attendance of children in schools. Improved Electricity also leads to having better teachers. It has also been highlighted as one of the factors that lead to improvement in learning, by allowing children to spend more hours on reading and using of electronic devices like computers and hence be able to access more information on their learning. Availability of electricity is essential for the functioning of hospitals and delivery of health services. This is because surgical operations can be done and vaccines can be refrigerated (Agenor and Moreno, 2006). According to Warwick and Diog (2004) air pollution from the burning of solid fuels kills over 1.6million people a year. More efficient electricity stoves would reduce this death. Thus households pay more for what they would have bought cheaply if purchased in bulk. Also some richer households buy generators which they operate when there is power outage. This is an additional burden to such households; apart from the cost of the generator they buy diesel or petrol to operate them. Poorer households that cannot afford the cost of generating set buy lanterns and candles. All these leads to additional expenses for the households. Apart from this, use of these back– up expose the households to threat like five outbreaks and health hazards.

Ariyo and Jerome (2004) confirm this that households purchases back up electricity to ease problem they usually encounter as a result of shortages.

2.4 Effect of Power Failure on the Commercial Sector

The commercial sectors also are affected by the impact of frequent power failure. Their Consumption of electricity ranges from usage as a source of light to usage in cold rooms for selling perishable things. Some use computers and electric typewriters to transact their business. When there is frequent erratic power supply, these cannot be used and it may even cause damages to both their wares and the equipments. Big commercial enterprise like the leventiesand others use it to power their 'lift'. With power failure, their business will be at standstill since people will not be able to move in and out of their shops. Some use it to power their air conditions and fans. When there is power failure, these will stop and there will be reduction in their efficiency.

2.5 Effect of Power Failure on the Industrial Sector

The industrial sector suffers a lot from frequent power failure. In the words of Adenikinju (2005) the problem of unreliability ranks high amongst issues in the business environment.Steel and Webster (1991) reported in their survey that electricity outage in small firms fallamong their top four constraints to expansion. Also, Kessides (1993) reported that inColumbia, rationing of power was estimated to reduce overall economic output by almost 1percent of GDP in 1992. All these are due to the frequent power failure which always affectsthese industries negatively. Evidence is provided by Reinikka and Stevenson (2002) in Uganda.They also emphasized how inadequate public infrastructure may adversely affect privateinvestment. According to Sambo (2005), the major factors contributing to the aboveunreliability and inefficiency in the power sector are: Frequent breakdown of generatingplants and equipment due to inadequate repairs and

maintenance; Lack of foreign exchangeto purchase needed spare parts on time; Obsolete transmission and distribution equipmentwhich frequently breakdown; Lack of skilled manpower; as well as Inadequacy of basicindustries to service the power sector. Oshodi and Oloni (2006) also confirm that the erraticpower supply in Nigeria can lead to slow growth in industry except the sector is revitalizedusing any of the Public-Private participation strategies.

2.6 Power Generation Stations in Nigeria.

The following tables 2.2, 2.3 and 2.4 below show the existing power stations in Nigeria.

Table 2.2: Existing Federal Government of Nigeria Power Stations – Hydroelectricity.

S/N	Generating Stations	Construction Year.	Location (State)	Installed capacity(MW)	Available Capacity(MW)
1.	Kainji Power station	1968	Niger	760	480
2.	Jebba Power station	1985	Niger	540	450
3.	Shiroro Power station	1989	Niger	600	450
Total				1,900	1,380

Source: Nigeria Power Review Series, 2010: PHCN Public department, Port Harcourt.

Table 2.3: Existing Federal Government of Nigeria Power Stations – Thermal Electricity

S/N.	Generating Station	Construction Year.	Location (State)	Installed Capacity(MW)	Available Capacity(MW)
1.	Egbim Power station	1986	Lagos	1,320	1100
2.	Geregu Power station	2007	Kogi	414	276
3.	Omotosho Power station	2007	Ondo	304	76
4.	Olorunsogo Power station	2008	Ogun	304	76
5.	Delta Power station	1966	Delta	900	300
6.	Sapele Power station	1978	Delta	1,020	90
7.	Afam Power station	1968	Rivers	726	60
8.	Calabar Power station	1934	Cross River	6.6	Nil
9.	Oji River Power station	1956	Enugu	10	Nil
Total				5,004	1,978

Source: Nigeria Power Review Series, 2010: PHCN Public department, Port Harcourt.

Table 2.4: Independent Power Project Generating Stations in Nigeria**.**

S/N.	Generating Stations	Location (State)	Installed Capacity(MW)	Available Capacity(MW)
1.	AES Power station	Lagos	224	224
2.	Shell-Afam Power station	Rivers	650	650
3.	AGIP-Okpai Power station	Delta	480	480
4.	ASG-Ibom power station	Akwa-Ibom	155	76
5.	RSG- Trans Amadi Power station	Rivers	100	24
6.	RSG- Omuku Power station	Rivers	150	30
Total			1,759	1,484

Source: Nigeria Power Review Series, 2010: PHCN Public department, Port Harcourt.

2.7Other Sources of Electricity

Electricity comes from many sources. Some of the sources like fossil fuels are disappearing because there is such a big demand for them. Scientists are researching new ways of generating electricity, so that if fossil fuels run out, there will be other sources. None of these alternative sources is ideal, but they all have their pros and cons (Warwick and Diog,2004).The most popular sources of electricity as explained below.

2.7.1 Solar Energy

Solar energy is the energy that comes from the sun. We capture solar energy through solar panels. This energy produces no pollution; also, it does not taint anything. About the equivalent of 22 million barrels of oil of solar energy hits the United States alone per day. This might sound like the perfect energy but it is costly and besides, you cannot be sure that the sun will shine brightly without cloud cover everywhere in the country every day.

2.7.2 Fossils fuel

Fossil fuel is a material that can be burned and that comes from the fossil remains of animals and plants, such as long-dead dinosaurs. Some examples of fossil fuels are coal, natural gas and petroleum. This source is currently available and it is not dependent upon the weather. Some of the problems of fossil fuel use are that it causes pollution, it is a non-renewable resource, and it needs to be mined from the earth. In addition, it causes acid precipitation, which destroys life in lakes.

2.7.3 Hydroelectric Energy

Hydroelectric energy is produced when water falls from a high place to a low place. A hydroelectric power station contains a turbine driven by falling water from a dam. The turbine drives the generator. This form of energy produces little pollution; in addition, it does not ruin the water. The water still can be used for other purposes. Hydroelectric power does not cost any more than fossil fuels. Another advantage is that there are a lot of lakes or rives where a dam can be built to produce energy. One disadvantage is that fish, such as salmon, cannot climb over the dam, so the dam changes the environment. Another disadvantage is that when a dam is built, a huge area is flooded to make a lake, so the water displaces the people and animals living there.

2.7.4 Nuclear Power

This energy is made by fusion or fission. It is produced in the reactor of a nuclear power station. The energy turns water into steam, which drives a turbine that powers a generator. Nuclear power produces lots of energy and can be made to power major cities. This energy, unlike other sources, produces lots of radioactive waste. If that waste gets released, it could cause devastation to a large area. In addition, it warms its wastewater, so fish in the nearby lake might lay their eggs at any time of year in the warmed spot. Some fish, such as trout, cannot live in warm water.

2.7.5 Wind Power

Wind power is produced by the wind turning a turbine. Wind power, through using windmills has been known for many centuries. This source of energy produces almost no pollution, and it is easy to capture in many parts of the United States. Some people think that the fields of windmills ruin the beauty of the land, and some other people are bothered by the noise generated by the windmills. In addition, in order to be effective the wind speed at a power site has to be over 12 kilometers per hour. Finally, this source of power is costly and requires special equipment.

2.8 Statistical and Regression Modeling Tool.

2.8.1 Frequency:

This is simply the number of occurrences of an observation.

2.8.2 Mean:

According to Kenney and Keeping(1962), the arithmetic mean of a set of values is the quantity commonly called the mean or the average. Given a set of samples $\{x_i\}$, the arithmetic mean is

$$\bar{x} \equiv \frac{1}{N}\sum_{i=1}^{N} x_i. \qquad [2.1]$$

For group data,

The mean is the arithmetic average and is given by

$$x = \frac{\Sigma x_i f_i}{\Sigma f_i} \qquad [2.2]$$

x = mean

x_i =class interval midpoint

f_i = frequencies of occurrences

However, the arithmetic mean is the special caseof the power mean and is one of the Pythagorean means. When viewed as an estimator for the mean of the underlying distribution (known as the population mean), the arithmetic mean of a sample is called the sample mean.

2.8.3 Standard Deviation

Nwaogazie (2006), defined standard deviation is a statistical measure of spread or variability. He stated that standard deviation is the root mean square (RMS) deviation of the values from their arithmetic mean. It is an indicator of the average deviation of occurrences, in a set of occurrences, from the mean occurrence using the mathematical expression below.

$$S.D = \sqrt{\frac{\Sigma f_i \left([\![x_i]\!] \right)^2}{\sum f_i} - \left(\frac{\sum x_i f_i}{\sum f_i} \right)^2} \qquad [2.3]$$

Where;

S.D = Standard deviation

f = frequencies

x_i = class interval midpoint

2.8.4 Regression Analysis

Regression analysis is a statistical tool for the investigation of relationships between variables. Usually, the investigator seeks to ascertain the causal effect of one variable upon another—the effect of a price increase upon demand, for example, or the effect of changes in the money supply upon the inflation rate. To explore such issues, the investigator assembles data on the underlying variables of interest and employs regression to estimate the quantitative effect of the causal variables upon the variable that they influence. The investigator also typically assesses the "statistical significance" of the estimated relationships, that is, the degree of confidence that the true relationship is close to the estimated relationship.

Regression techniques have long been central to the field of economic statistics ("econometrics"). Increasingly, they have become important to lawyers and legal policy makers as well. Regression has been offered as evidence of liability under Title VII of the Civil Rights Act of 1964:

1. As evidence of racial bias in death penalty litigation.
2. As evidence of damages in contract actions.
3. As evidence of violations under the Voting Rights Act.
4. As evidence of damages in antitrust litigation.

Nwaogazie (2006), said that regression analysis tends to determine correlation amongst variables x and y. the correlation is express in the form of coefficient. We use spearman's correlation coefficient formula to achieve.

$$r_s = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}} \qquad [2.4]$$

Where;

r_s = Spearman's correlation coefficient

x = observation

y = observation

2.9 Trans-Amadi community brief

Trans-Amadi is located in Port Harcourt which is a large city in the South-South geopolitical zone of Nigeria. It happened to be amongst the fastest growing city within the region in view of the Oil exploitation and exploration activities going on in the area. Hence this attributes to the astronomical rate of growth in its power supply load demand.

2.10 Review of Past works

A review of the literature reveals numerous studies directed to estimate consumeroutage costs. Krohm (1978) considered that the impacts of outages upon residential consumer can be measured as the disruption of household preferred consumption pattern by time-of-day. A measure of the resultant reduction in the household welfare level due to inconvenience, loss leisure, etc., is its willingness-to-pay to avoid the outages. Koval and Billinton (1979) developed a statistical method and showed that the outage costs vary in a non-linear way with durations. Munasinghe (1980), considered that the main outage costs is the loss of evening leisure time which can be evaluated at the household income. The Swedish study was obtained by direct questioning to the customers and through worked examples based on actual losses, household activities, and leisure time. Wacker*et al.*,and Billinton*et al. (1982)*used three survey approaches. Two of these approaches were considered with tariff changes that would be commensurate with

specified changes in system reliability, while the third approach was concerned with the type of preparatory actions that consumers may take during outages periods. Also Billinton*et al, (1982)*relate the costs to the expected energy not served by using a frequency and duration approach and Mont Carlo simulation. Shaalan, (1989)used a customer survey to estimate the outage costs for major customer's categories *(i.e.,* residential, commercial, industrial). The method adopted was based on the customer's survey to assess damage that may result due to power outages. Corwin and Miles in their work discussed the impacts of power outages upon social life. Markel *et al., (1976)* derived residential customer losses on the basis of the *Impact ofPower Outages on Residential...* 113 depreciation of all household electrical appliances for the duration of power outages. Lundberg discussed survey results from Swedish, French, and British utilities concerning customer's costs of power outages. These results were estimated on basis oflost leisure time and income rate. The monetary value was determined using average residential loads and occupancy. Sanghvi, (1983)discussed the value of service (VOS) as an approach - which is based on customer choices regarding reliability worth and servicecosts - to be evaluated and incorporated into the planning process.The data extracted from these studies are 'of significant contribution to the reliability-based power system planning. These approaches, however, are not strictlycomparable, the major reason being that the cases, scenarios, data, and modeling techniques are not identical.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The previous chapter elaborated extensively on the literature review of the impact of power outages on consumers, using five cold rooms as a case study. However in this chapter, the procedure adopted for gathering data and how these data are analyzed are explained.To accomplish this task, the study is divided into two parts:

i. The first part of this workaddressed customer's responses through questionnaires.

ii. The second part applied spearman's statistical model to analyze the impact of the outages on consumers.The choice of spearman analytical method was informed by irregularity of the data obtained, since one cannot really predict exactly how long it takes to restore power.

3.2 Description of the cases

3.2.1 Cold Room 1: the Genesis cold house Nigeria limited is located at 54Oginigba Port-Harcourt. It was established in 1990 by Mr. Genesis Agu, with a storage capacity of 3500litres, employing over ten workers

3.2.2 Cold Room 2: the cold ventures Nig. Ltd is located at coca cola road, trans-amadi. Port Harcourt. It was established in the year 2002 byMrChiziOvunda. It has a storage capacity of about 4300litres, employing over twelve staff.

3.2.3 Cold Room 3: The Anzzy investment Nig ltd. Elekahia road, Trans-amadi Port Harcourt. It was established in the year 2005 by Mrs.SerahAlade. It has a storage capacity of about 3200litres and a staff strength of seven on its payroll.

3.2.4 Cold Room 4: The new life beverages and cold room, Rainbow crescent Trans-amadi Port hacourt. Is owned and managed by Mrs. Patience Idah, it has a storage capacity of 3000litres with a staff strength of five.

3.2.5 Cold Room 5: The briggsNig ltd, 12 Abuloma road, Trans-amadi, port Harcourt. Is owned by Mr. Briggs Dagogo. It has a storage capacity of 3000litres with staff strength of five.

3.2 Data collection

The data use for analyzing power outages were collected from the daily book of record of power supply outages of Power Holding Company of Nigeria (PHCN). Each parameter of the data was recorded during power outages according to the workers of PHCN. Also, the workers gave explanations for records that were not clear in the data.

Meanwhile, five cold rooms have been selected within the area under consideration to be used in weighing the cost of power supplied by PHCN and the cost of powering with a private generating set. The data used for these costs modeling were gathered using questionnaires. Each of these questionnaires contains the cost spent on power utility for twenty-four different months (2yrs). The five different cold room's financial and technical officers supplied the information from their respective power utility records. The following tables 3.1-3.9 below shows data collected within a period of three years.

Table 3.1:Frequency Distribution of Power Outages for 2009.

Hourly Duration	Time Interval.	January	March	June	September
12 a.m - 1 a.m	0.00 -0.90	3.050	6.050	8.050	7.050
1 a.m - 2 a.m	1.00 - 1.90	4.175	1.175	6.175	5.175
2 a.m - 3 a.m	2.00 - 2.90	1.850	4.050	1.650	3.850
3 a.m - 4 a.m	3.00 - 3.90	2.334	3.01	1.005	4.329
4 a.m - 5 a.m	4.00 - 4.90	3.400	1.001	2.200	2.200
5 a.m - 6 a.m	5.00 - 5.90	2.692	0.693	1.682	1.792
6 a.m - 7 a.m	6.00 - 6.90	1.123	0.361	0.542	0.942
7 a.m - 8 a.m	7.00 - 7.90	0.422	0.844	0.944	0.322
8 a.m - 9 a.m	8.00 - 8.90	0.325	0.725	0.550	0.500
9 a.m - 10 a.m	9.00 - 9.90	0.342	0.142	0.602	0.282
10 a.m - 11 a.m	10.00 - 10.90	0.100	0.500	0.400	0.200
11 a.m - 12 p.m	11.00 - 11.90	0.200	0.200	0.200	0.20
12 p.m - 1 p.m	12.00 - 12.90	0.250	0.050	0.100	0.200
1 p.m - 2 p.m	13.00 - 13.90	0.250	0.400	0.350	0.300
2 p.m - 3 p. m	14.00 - 14.90	0.027	0.007	0.023	0.011

3 p.m - 4 p. m	15.00 - 15.90	0.157	0.377	0.256	0.278
4 p.m - 5 p. m	16.00 -16.90	0.011	0.055	0.045	0.021
5 p.m - 6 p. m	17.00 - 17.90	0.025	0.025	0.025	0.025
6 p.m - 7 p. m	18.00 - 18.90	0.108	0.200	0.016	0.108
7 p.m - 8 p. m	19.00 - 19.90	0.002	0.008	0.012	0.010
8 p.m - 9 p. m	20.00 - 20.90	0.100	0.000	0.030	0.070
9 p.m - 10 p. m	21.00- 21.90	0.005	0.045	0.035	0.015
10 p.m - 11 p. m	22.00 - 22.90	0.041	0.033	0.053	0.031
11 p.m - 12 a. m	23.00 - 23.90	0.049	0.067	0.036	0.080

Source: PHCN daily logbook (2009 to2011)

Table 3.2:Frequency Distribution of Power Outages for 2010.

Hourly Duration	**Time Interval.**	**January**	**March**	**June**	**September**
12 a.m - 1 a.m	0.00 -0.90	2.100	7.000	6.025	9.075
1 a.m - 2 a.m	1.00 - 1.90	3.073	2.277	6.170	5.180
2 a.m - 3 a.m	2.00 - 2.90	1.650	3.250	2.640	3.860
3 a.m - 4 a.m	3.00 - 3.90	4.114	1.230	2.000	3.334
4 a.m - 5 a.m	4.00 - 4.90	1.200	2.200	3.300	2.100
5 a.m - 6 a.m	5.00 - 5.90	0.692	2.495	1.880	1.792
6 a.m - 7 a.m	6.00 - 6.90	1.023	0.451	0.352	1.142
7 a.m - 8 a.m	7.00 - 7.90	0.632	0.634	0.746	0.520
8 a.m - 9 a.m	8.00 - 8.90	0.325	0.725	0.550	0.500
9 a.m - 10 a.m	9.00 - 9.90	0.132	0.252	0.401	0.483
10 a.m - 11 a.m	10.00 - 10.90	0.050	0.525	0.325	0.300
11 a.m - 12 p.m	11.00 - 11.90	0.300	0.100	0.020	0.080
12 p.m - 1 p.m	12.00 - 12.90	0.225	0.075	0.095	0.205
1 p.m - 2 p.m	13.00 - 13.90	0.125	0.525	0.250	0.400

2 p.m - 3 p. m	14.00 - 14.90	0.017	0.017	0.013	0.021
3 p.m - 4 p. m	15.00 - 15.90	0.257	0.288	0.367	0.178
4 p.m - 5 p. m	16.00 -16.90	0.022	0.044	0.034	0.032
5 p.m - 6 p. m	17.00 - 17.90	0.020	0.035	0.015	0.030
6 p.m - 7 p. m	18.00 - 18.90	0.158	0.150	0.006	0.118
7 p.m - 8 p. m	19.00 - 19.90	0.000	0.010	0.002	0.020
8 p.m - 9 p. m	20.00 - 20.90	0.075	0.025	0.020	0.080
9 p.m - 10 p. m	21.00- 21.90	0.025	0.025	0.015	0.035
10 p.m - 11 p. m	22.00 - 22.90	0.011	0.063	0.023	0.061
11 p.m - 12 a. m	23.00 - 23.90	0.042	0.069	0.038	0.083

Source: PHCN daily logbook (2009 to2011)

Table 3.3:Frequency Distribution of Power Outages for 2011.

Hourly Duration	Time Interval.	January	March	June	September
12 a.m - 1 a.m	0.00 -0.90	6.025	3.075	7.040	8.060
1 a.m - 2 a.m	1.00 - 1.90	2.025	3.275	4.225	7.175
2 a.m - 3 a.m	2.00 - 2.90	0.550	4.350	4.625	1.875
3 a.m - 4 a.m	3.00 - 3.90	4.334	3.000	1.015	2.329
4 a.m - 5 a.m	4.00 - 4.90	3.200	1.201	1.200	3.200
5 a.m - 6 a.m	5.00 - 5.90	2.702	0.693	1.692	1.772
6 a.m - 7 a.m	6.00 - 6.90	1.143	0.542	0.342	0.940
7 a.m - 8 a.m	7.00 - 7.90	0.622	0.864	0.744	0.302
8 a.m - 9 a.m	8.00 - 8.90	0.125	0.625	0.650	0.700
9 a.m - 10 a.m	9.00 - 9.90	0.242	0.222	0.622	0.282
10 a.m - 11 a.m	10.00 - 10.90	0.300	0.300	0.100	0.500
11 a.m - 12 p.m	11.00 - 11.90	0.070	0.330	0.100	0.300
12 p.m - 1 p.m	12.00 - 12.90	0.150	0.150	0.200	0.100
1 p.m - 2 p.m	13.00 - 13.90	0.250	0.350	0.350	0.350

2 p.m - 3 p. m	14.00 - 14.90	0.028	0.006	0.013	0.021
3 p.m - 4 p. m	15.00 - 15.90	0.257	0.277	0.356	0.178
4 p.m - 5 p. m	16.00 -16.90	0.022	0.044	0.034	0.032
5 p.m - 6 p. m	17.00 - 17.90	0.050	0.000	0.005	0.045
6 p.m - 7 p. m	18.00 - 18.90	0.078	0.280	0.016	0.058
7 p.m - 8 p. m	19.00 - 19.90	0.006	0.004	0.020	0.012
8 p.m - 9 p. m	20.00 - 20.90	0.000	0.120	0.030	0.050
9 p.m - 10 p. m	21.00- 21.90	0.025	0.025	0.025	0.025
10 p.m - 11 p. m	22.00 - 22.90	0.052	0.022	0.051	0.033
11 p.m - 12 a. m	23.00 - 23.90	0.019	0.092	0.036	0.085

Source: PHCN daily logbook (2009 to2011)

Table 3.4:Cumulative Frequency Distribution of Power Outages For the Three Years (2009, 2010 and 2011).

Hourly Duration	Time Interval.	Frequency of Power Outages
12 a.m - 1 a.m	0.00 - 0.90	72.6
1 a.m - 2 a.m	1.00 - 1.90	50.1
2 a.m - 3 a.m	2.00 - 2.90	34.2
3 a.m - 4 a.m	3.00 - 3.90	32
4 a.m - 5 a.m	4.00 - 4.90	26.4
5 a.m - 6 a.m	5.00 - 5.90	20.3
6 a.m - 7 a.m	6.00 - 6.90	8.9
7 a.m - 8 a.m	7.00 - 7.90	7.6
8 a.m - 9 a.m	8.00 - 8.90	6.3
9 a.m - 10 a.m	9.00 - 9.90	4.1
10 a.m - 11 a.m	10.00 - 10.90	3.6
11 a.m - 12 p.m	11.00 - 11.90	2.4
12 p.m - 1 p.m	12.00 - 12.90	1.8
1 p.m - 2 p.m	13.00 - 13.90	3.9
2 p.m - 3 p. m	14.00 - 14.90	0.2
3 p.m - 4 p. m	15.00 - 15.90	3.2
4 p.m - 5 p. m	16.00 - 16.90	0.4
5 p.m - 6 p. m	17.00 - 17.90	0.3
6 p.m - 7 p. m	18.00 - 18.90	1.3
7 p.m - 8 p. m	19.00 - 19.90	0.1
8 p.m - 9 p. m	20.00 - 20.90	0.6
9 p.m - 10 p. m	21.00- 21.90	0.3
10 p.m - 11 p. m	22.00 - 22.90	0.5
11 p.m - 12 a. m	23.00 - 23.90	0.7

3.3.1 Cost Analysis of Cold Room 1(GenesisColdhouse Nig. Ltd, 54 Rumuomasi, P/Harcourt.

Table 3.5: Cost Data for Cold Room 1.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y
1	31.25	64
2	29.82	63.98
3	28.49	59.86
4	30.92	64.23
5	26.45	60.92
6	29.39	64
7	31.18	63.54
8	30.27	63.92
9	29.86	57.89
10	25.16	64.12
11	27.91	63.78
12	28.87	62.92
13	30.62	64.17
14	29.29	62.43
15	29.73	58.36
16	31.19	63.28
17	26.245	59.06
18	28.53	62.92
19	26.13	60.34
20	26.98	58.58
21	27.56	59.23
22	30.39	60.86
23	31.24	63.94
24	29.06	61.24

3.3.2 Cost Analysis of Cold Room 2 (ColdMan Ventures Nig. Ltd, Coca Cola Rd, Trans-Amadi, P/Harcourt)

Table 3.6: Cost Data for Cold Room 2.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y
1	30.25	64.45
2	28.85	62.98
3	29.49	62.86
4	31.92	64.23
5	27.45	60.92
6	29.39	64.5
7	30.18	63.54
8	30.27	63.82
9	29.76	59.89
10	26.16	63.32
11	29.91	64.78
12	28.97	63.82
13	30.76	64.27
14	29.29	63.43
15	28.73	58.36
16	31.19	62.47
17	28.45	59.06
18	28.73	63.92
19	26.13	61.34
20	25.98	59.58
21	29.56	59.27
22	30.39	61.86
23	31.74	63.74
24	30.06	62.24

3.3.3 Cost Analysis of Cold Room 3 (Anzzy Investment Ltd, Elekahia Rd, Trans-Amadi, P/Harcout.)

Table 3.7: Cost Data for Cold Room 3.

S/N	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y
1	31.65	63.65
2	29.87	63.88
3	29.59	63.86
4	31.72	64.23
5	28.45	63.92
6	28.59	63.75
7	32.48	62.56
8	34.27	63.82
9	29.96	63.89
10	28.21	59.32
11	28.91	64.78
12	29.96	63.82
13	30.76	63.47
14	31.49	63.63
15	29.73	63.36
16	31.19	61.47
17	29.45	59.06
18	28.73	63.83
19	27.23	62.34
20	25.98	58.58
21	27.56	60.27
22	30.49	61.26
23	31.74	63.74
24	31.06	63.24

3.3.4 Cost Analysis of Cold Room 4 (New life Beverages and Cold Room, Rainbow Crescent, Trans-Amadi, P/H.)

Table 3.8: Cost Data for Cold Room 4.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y
1	30.65	64.15
2	28.87	63.98
3	27.69	61.86
4	29.72	62.23
5	27.45	60.92
6	29.59	62.54
7	31.58	60.46
8	36.37	64.82
9	27.87	61.78
10	29.25	57.32
11	26.91	64.78
12	29.96	63.72
13	31.76	63.47
14	31.49	63.63
15	29.73	63.36
16	25.19	61.47
17	29.45	63.06
18	28.73	57.83
19	27.23	62.34
20	27.98	58.58
21	27.56	62.47
22	29.69	60.26
23	30.74	63.74
24	29.06	62.24

3.3.5 Cost Analysis of Cold Room 5 (Briggs Nig. Ltd, 12 Abuloma Rd, Trans-Amadi, P/Harcourt.)

Table 3.9: Cost Data for Cold Room 5.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y
1	30.2	63.98
2	28.82	57.08
3	30.49	60.86
4	30.92	58.2
5	31.45	60.52
6	29.39	63.45
7	31.18	62.56
8	30.2	62.92
9	29.86	57.89
10	26.16	63.12
11	28.94	63.43
12	27.89	60.92
13	30.62	57.17
14	28.28	63.43
15	26.83	58.36
16	30.19	62.28
17	28.24	56.06
18	30.53	62.42
19	27.1	59.34
20	25.98	58.68
21	25.56	56.72
22	26.39	59.22
23	27.82	58.92
24	28.82	57.26

CHAPTER FOUR

CALCULATIONS, RESULTS AND DISCUSSION

4.1 Results of the Study

In this chapter statistical and regression interpretations of the results will be seen as well as customer's response of the questionnaire, after which, inferences will be drawn. This chapter is been segregated into various subsections as this will be seen subsequently in a progressive manner.

4.1.1Standard Deviation Result

Considering the number of times in which power outages can most likely occur, within an interval of one hour, starting from the 0^{th} hour of the day to the 24^{th} hour of the day, table 4.1 below has been developed to analyze the frequency distribution of power outages so as to ascertain the possibilities of experiencing repeatable power outages, within the area under study.

Table 4.1: Frequency Distribution of Power Outages for a Period of Three Years.

Time Interval.	**Midpoint of Time interval (x_i).**	**Frequency of Power Outages (f_i).**	x_i^2	$f_i x_i$	$f_i x_i^2$
0.00 - 0.90	0.45	72.6	0.2025	32.67	14.7015
1.00 - 1.90	1.45	50.1	2.1025	72.645	105.3353
2.00 - 2.90	2.45	34.2	6.0025	83.79	205.2855
3.00 - 3.90	3.45	32	11.9025	110.4	380.88
4.00 - 4.90	4.45	26.4	19.8025	117.48	522.786
5.00 - 5.90	5.45	20.3	29.7025	110.635	602.9608
6.00 - 6.90	6.45	8.9	41.6025	57.405	370.2623
7.00 - 7.90	7.45	7.6	55.5025	56.62	421.819
8.00 - 8.90	8.45	6.3	71.4025	53.235	449.8358
9.00 - 9.90	9.45	4.1	89.3025	38.745	366.1403
10.00 - 10.90	10.45	3.6	109.2025	37.62	393.129
11.00 - 11.90	11.45	2.4	131.1025	27.48	314.646
12.00 - 12.90	12.45	1.8	155.0025	22.41	279.0045
13.00 - 13.90	13.45	3.9	180.9025	52.455	705.5198
14.00 - 14.90	14.45	0.2	208.8025	2.89	41.7605
15.00 - 15.90	15.45	3.2	238.7025	49.44	763.848
16.00 - 16.90	16.45	0.4	270.6025	6.58	108.241
17.00 - 17.90	17.45	0.3	304.5025	5.235	91.35075
18.00 - 18.90	18.45	1.3	340.4025	23.985	442.5233
19.00 - 19.90	19.45	0.1	378.3025	1.945	37.83025
20.00 - 20.90	20.45	0.6	418.2025	12.27	250.9215
21.00- 21.90	21.45	0.3	460.1025	6.435	138.0308
22.00 - 22.90	22.45	0.5	504.0025	11.225	252.0013
23.00 - 23.90	23.45	0.7	549.9025	16.415	384.9318
	$\sum x =$ 286.8	$\sum f =$ 281.8	$\sum x^2 =$ 4577.26	$\sum fx =$ 1010.01	$\sum fx^2 =$ 7643.745

To obtain the mean (M) for the distribution of the power outages stipulated in the table above , we employ the formula of calculating the arithmetic mean for group data, as seen in equation 2.1

$$M = \frac{\sum x_i f_i}{\sum f_i} \qquad [4.1]$$

Where;

M = mean

x_i =Time interval midpoint

f_i = frequencies of outages

Substituting values into the equation above yields;

$$M = \frac{1010.01}{281.8} \quad [4.2]$$

. : M = 3.58

Having obtained the mean, to get the standard deviation for the power outages, we employ equation 2.3 as seen below.

$$S.D = \sqrt{\frac{\sum f_i(x_i)^2}{\sum f_i} - \left(\frac{\sum x_i f_i}{\sum f_i}\right)^2} \quad [4.3]$$

This equation can further be written as;

$$S.D = \sqrt{\frac{\sum f_i x_i^2}{\sum f_i} - M^2} \quad [4.4]$$

where;

S.D = Standard deviation

M = mean

f = frequencies

x_i = interval midpoint

Therefore, the standard deviation of the power outages is;

$$S.D = \sqrt{\frac{7643.745}{281.8} - 3.58^2} \quad [4.5]$$

$$S.D = \sqrt{27.12 - 12.82} S.D = \sqrt{14.30}$$

S.D = 3.78

4.1.2 Cost Analysis of the Different Cold Rooms by Statistical Mean

a) Cost Analysis of Cold Room 1: Genesis Cold house Nig. Ltd, 54 Rumuomasi, P/Harcourt.

Table 4.2: Statistical Analysis of Cold Room 1.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y	(MX-X) x	(MY-Y) y	x^2	y^2	xy
1	31.25	64	-2.23	-2.02	4.9729	4.0804	4.5046
2	29.82	63.98	-0.8	-2	0.64	4	1.6
3	28.49	59.86	0.53	2.12	0.2809	4.4944	1.1236
4	30.92	64.23	-1.9	-2.25	3.61	5.0625	4.275
5	26.45	60.92	2.57	1.06	6.6049	1.1236	2.7242
6	29.39	64	-0.37	-2.02	0.1369	4.0804	0.7474
7	31.18	63.54	-2.16	-1.56	4.6656	2.4336	3.3696
8	30.27	63.92	-1.25	-1.94	1.5625	3.7636	2.425
9	29.86	57.89	-0.84	4.09	0.7056	16.7281	-3.4356
10	25.16	64.12	3.86	-2.14	14.8996	4.5796	-8.2604

11	27.91	63.78	1.11	-1.8	1.2321	3.24	-1.998
12	28.87	62.92	0.15	-0.94	0.0225	0.8836	-0.141
13	30.62	64.17	-1.6	-2.19	2.56	4.7961	3.504
14	29.29	62.43	-0.27	-0.45	0.0729	0.2025	0.1215
15	29.73	58.36	-0.71	3.62	0.5041	13.1044	-2.5702
16	31.19	63.28	-2.17	-1.3	4.7089	1.69	2.821
17	26.245	59.06	2.775	2.92	7.700625	8.5264	8.103
18	28.53	62.92	0.49	-0.94	0.2401	0.8836	-0.4606
19	26.13	60.34	2.89	1.64	8.3521	2.6896	4.7396
20	26.98	58.58	2.04	3.4	4.1616	11.56	6.936
21	27.56	59.23	1.46	2.75	2.1316	7.5625	4.015
22	30.39	60.86	-1.37	1.12	1.8769	1.2544	-1.5344
23	31.24	63.94	-2.22	-1.96	4.9284	3.8416	4.3512
24	29.06	61.24	-0.04	0.74	0.0016	0.5476	-0.0296
	$\sum X =$ 696.535	$\sum Y =$ 1487.57			$\sum x^2 =$ 76.572325	$\sum y^2 =$ 111.1285	$\sum xy =$ 36.9309

MX = Mean Cost of Paying PHCN Bill (x 1000 Naira)

Thus,

Actual Mean Cost of Paying PHCN Bill = 29.02 x 1000 Naira

Actual Mean Cost of Paying PHCN Bill = 29,020 Naira.

MY= Mean Cost of Running a Private Generating Set(Diesel Engine)

(x1000 Naira)

Thus,

Actual Mean Cost of Running a Private Generating Set = 61.98 x 1000 Naira

Actual Mean Cost of Running a Private Generating Set = 61,980 Naira.

b) Cost Analysis of Cold Room 2: ColdMan Ventures Nig. Ltd, Coca Cola Rd, Trans-Amadi, P/Harcourt.

Table 4.3: Statistical Analysis of Cold Room 2.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y	(MX- X) X	(MY-Y) y	x^2	y^2	xy
1	30.25	64.45	-0.94	-2.01	0.8836	4.0401	1.8894
2	28.85	62.98	0.46	-0.54	0.2116	0.2916	-0.2484
3	29.49	62.86	-0.18	-0.42	0.0324	0.1764	0.0756
4	31.92	64.23	-2.61	-1.79	6.8121	3.2041	4.6719
5	27.45	60.92	1.86	1.52	3.4596	2.3104	2.8272
6	29.39	64.5	-0.08	-2.06	0.0064	4.2436	0.1648
7	30.18	63.54	-0.87	-1.1	0.7569	1.21	0.957
8	30.27	63.82	-0.96	-1.38	0.9216	1.9044	1.3248
9	29.76	59.89	-0.45	2.55	0.2025	6.5025	-1.1475
10	26.16	63.32	3.15	-0.88	9.9225	0.7744	-2.772

11	29.91	64.78	-0.6	-2.34	0.36	5.4756	1.404
12	28.97	63.82	0.34	-1.38	0.1156	1.9044	-0.4692
13	30.76	64.27	-1.45	-1.83	2.1025	3.3489	2.6535
14	29.29	63.43	0.02	-0.99	0.0004	0.9801	-0.0198
15	28.73	58.36	0.58	4.08	0.3364	16.6464	2.3664
16	31.19	62.47	-1.88	-0.03	3.5344	0.0009	0.0564
17	28.45	59.06	0.86	3.38	0.7396	11.4244	2.9068
18	28.73	63.92	0.58	-1.48	0.3364	2.1904	-0.8584
19	26.13	61.34	3.18	1.1	10.1124	1.21	3.498
20	25.98	59.58	3.33	2.86	11.0889	8.1796	9.5238
21	29.56	59.27	-0.25	3.17	0.0625	10.0489	-0.7925
22	30.39	61.86	-1.08	0.58	1.1664	0.3364	-0.6264
23	31.74	63.74	-2.43	-1.3	5.9049	1.69	3.159
24	30.06	62.24	-0.75	0.2	0.5625	0.04	-0.15
	$\sum X =$ 703.61	$\sum Y =$ 1498.65			$\sum x^2 =$ 59.6321	$\sum y^2 =$ 88.1335	$\sum xy =$ 30.3944

MX = MeanCost of Paying PHCN Bill (x 1000 Naira)

Thus,

Actual Mean Cost of Paying PHCN Bill = 29.31 x 1000 Naira

Actual Mean Cost of Paying PHCN Bill = 29,310 Naira.

MY= Mean Cost of Running a Private Generating Set (Diesel Engine)

(x1000 Naira)

Thus,

Actual Mean Cost of Running a Private Generating Set = 62.44 x 1000 Naira

Actual Mean Cost of Running a Private Generating Set = 62440 Naira.

c) Cost Analysis of Cold Room 3: Anzzy Investment Ltd, Elekahia Rd, Trans-Amadi, P/Harcout.

Table 4.4: Statistical Analysis of Cold Room 3.

S/N	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y	(MX- X) X	(MY-Y) y	x^2	y^2	xy
1	31.65	63.65	-1.69	-0.92	2.8561	0.8464	1.5548
2	29.87	63.88	0.09	-1.15	0.0081	1.3225	-0.1035
3	29.59	63.86	-0.57	-1.13	0.3249	1.2769	0.6441
4	31.72	64.23	-2.7	-1.5	7.29	2.25	4.05
5	28.45	63.92	0.57	-1.19	0.3249	1.4161	-0.6783
6	28.59	63.75	0.43	-1.02	0.1849	1.0404	-0.4386
7	32.48	62.56	-3.46	0.17	11.9716	0.0289	-0.5882
8	34.27	63.82	-5.25	-1.09	27.5625	1.1881	5.7225
9	29.96	63.89	-0.94	-1.16	0.8836	1.3456	1.0904
10	28.21	59.32	0.81	3.41	0.6561	11.6281	2.7621

11	28.91	64.78	0.11	-2.05	0.0121	4.2025	-0.2255
12	29.96	63.82	-0.94	-1.09	0.8836	1.1881	1.0246
13	30.76	63.47	-1.74	-0.74	3.0276	0.5476	1.2876
14	31.49	63.63	-2.47	-0.9	6.1009	0.81	2.223
15	29.73	63.36	-0.71	-0.63	0.5041	0.3969	0.4473
16	31.19	61.47	-2.17	1.26	4.7089	1.5876	-2.7342
17	29.45	59.06	-0.43	3.67	0.1849	13.4689	-1.5781
18	28.73	63.83	0.29	-1.1	0.0841	1.21	-0.319
19	27.23	62.34	1.79	0.39	3.2041	0.1521	0.6981
20	25.98	58.58	3.04	4.15	9.2416	17.2225	12.616
21	27.56	60.27	1.46	2.46	2.1316	6.0516	3.5916
22	30.49	61.26	-1.47	1.47	2.1609	2.1609	-2.1609
23	31.74	63.74	-2.72	-1.01	7.3984	1.0201	2.7472
24	31.06	63.24	-2.04	-0.51	4.1616	0.2601	1.0404
	$\sum X =$ 719.07	$\sum Y =$ 1505.73			$\sum x^2 =$ 95.8671	$\sum y^2 =$ 72.6219	$\sum xy =$ 32.6734

MX = MeanCost of Paying PHCN Bill (x 1000 Naira)

Thus,

Actual Mean Cost of Paying PHCN Bill = 29.96 x 1000 Naira

Actual Mean Cost of Paying PHCN Bill = 29,960 Naira.

MY= Mean Cost of Running a Private Generating Set (Diesel Engine)

(x1000 Naira)

Thus,

Actual Mean Cost of Running a Private Generating Set = 62.73 x 1000 Naira

Actual Mean Cost of Running a Private Generating Set = 62,730 Naira.

d) Cost Analysis Of Cold Room 4: New life Beverages and Cold Room, Rainbow Crescent, Trans-Amadi, P/H.

Table 4.5: Statiscal Analysis of Cold Room 4.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y	(MX- X) x	(MY-Y) y	x^2	y^2	xy
1	30.65	64.15	-1.3	-2.03	1.69	4.1209	2.639
2	28.87	63.98	0.48	-1.86	0.2304	3.4596	-0.8928
3	27.69	61.86	1.66	0.26	2.7556	0.0676	0.4316
4	29.72	62.23	-0.37	-0.11	0.1369	0.0121	0.0407
5	27.45	60.92	1.9	1.2	3.61	1.44	2.28
6	29.59	62.54	-0.24	-0.42	0.0576	0.1764	0.1008
7	31.58	60.46	-2.23	1.66	4.9729	2.7556	-3.7018
8	36.37	64.82	-7.02	-2.7	49.2804	7.29	18.954
9	27.87	61.78	1.48	0.34	2.1904	0.1156	0.5032
10	29.25	57.32	0.1	4.8	0.01	23.04	0.48
11	26.91	64.78	2.44	-2.66	5.9536	7.0756	-6.4904
12	29.96	63.72	-0.61	-1.6	0.3721	2.56	0.976
13	31.76	63.47	-2.41	-1.35	5.8081	1.8225	3.2535
14	31.49	63.63	-2.14	-1.51	4.5796	2.2801	3.2314

15	29.73	63.36	-0.38	-1.24	0.1444	1.5376	0.4712
16	25.19	61.47	4.16	0.65	17.3056	0.4225	2.704
17	29.45	63.06	-0.1	-0.94	0.01	0.8836	0.094
18	28.73	57.83	0.62	4.29	0.3844	18.4041	2.6598
19	27.23	62.34	2.12	-0.22	4.4944	0.0484	-0.4664
20	27.98	58.58	1.37	3.54	1.8769	12.5316	4.8498
21	27.56	62.47	1.79	-0.35	3.2041	0.1225	-0.6265
22	29.69	60.26	-0.34	1.86	0.1156	3.4596	-0.6324
23	30.74	63.74	-1.39	-1.62	1.9321	2.6244	2.2518
24	29.06	62.24	0.29	-0.12	0.0841	0.0144	-0.0348
	$\sum X =$ 704.52	$\sum Y =$ 1491.01			$\sum x^2 =$ 111.1992	$\sum y^2 =$ 96.2647	$\sum xy =$ 33.0757

MX = MeanCost of Paying PHCN Bill (x 1000 Naira)

Thus,

Actual Mean Cost of Paying PHCN Bill = 29.35 x 1000 Naira

Actual Mean Cost of Paying PHCN Bill = 29,350 Naira.

MY= Mean Cost of Running a Private Generating Set(Diesel Engine)

(x1000 Naira)

Thus,

Actual Mean Cost of Running a Private Generating Set = 62.12 x 1000 Naira

Actual Mean Cost of Running a Private Generating Set = 62,120 Naira.

e) Cost Analysis of Cold Room 5: Briggs Nig. Ltd, 12 Abuloma Rd, Trans-Amadi, P/Harcourt.

Table 4.6: Statistical Analysis of Cold Room 5.

S/N.	Cost of Paying PHCN Bill (x 1000 Naira) X	Cost of Running a Private Generating Set(Diesel Engine) (x 1000 Naira) Y	(MX- X) x	(MY-Y) y	x^2	y^2	xy
1	30.2	63.98	-1.07	-3.15	1.1449	9.9225	3.3705
2	28.82	57.08	0.31	3.75	0.0961	14.0625	1.1625
3	30.49	60.86	-1.36	-0.03	1.8496	0.0009	0.0408
4	30.92	58.2	-1.79	2.63	3.2041	6.9169	-4.7077
5	31.45	60.52	-2.32	0.31	5.3824	0.0961	-0.7192
6	29.39	63.45	-0.26	-2.62	0.0676	6.8644	0.6812
7	31.18	62.56	-2.05	-1.73	4.2025	2.9929	3.5465
8	30.2	62.92	-1.07	-2.09	1.1449	4.3681	2.2363
9	29.86	57.89	-0.73	2.94	0.5329	8.6436	-2.1462
10	26.16	63.12	2.97	-2.29	8.8209	5.2441	-6.8013
11	28.94	63.43	0.19	-2.6	0.0361	6.76	-0.494
12	27.89	60.92	1.24	-0.09	1.5376	0.0081	-0.1116
13	30.62	57.17	-1.49	3.66	2.2201	13.3956	-5.4534
14	28.28	63.43	0.85	-2.6	0.7225	6.76	-2.21
15	26.83	58.36	2.3	2.47	5.29	6.1009	5.681
16	30.19	62.28	-1.06	-1.45	1.1236	2.1025	1.537
17	28.24	56.06	0.89	4.77	0.7921	22.7529	4.2453

18	30.53	62.42	-1.4	-1.59	1.96	2.5281	2.226
19	27.1	59.34	2.03	1.49	4.1209	2.2201	3.0247
20	25.98	58.68	3.15	2.15	9.9225	4.6225	6.7725
21	25.56	56.72	3.57	4.11	12.7449	16.8921	14.6727
22	26.39	59.22	2.74	1.61	7.5076	2.5921	4.4114
23	27.82	58.92	1.31	1.91	1.7161	3.6481	2.5021
24	28.82	57.26	0.31	3.57	0.0961	12.7449	1.1067
	$\sum X =$ 691.86	$\sum Y =$ 1444.79			$\sum x^2 =$ 76.236	$\sum y^2 =$ 162.2399	$\sum xy =$ 34.5738

MX = Mean Cost of Paying PHCN Bill (x 1000 Naira)

Thus,

Actual Mean Cost of Paying PHCN Bill = 28.82 x 1000 Naira

Actual Mean Cost of Paying PHCN Bill = 28,820 Naira.

MY= Mean Cost of Running a Private Generating Set (Diesel Engine)

(x1000 Naira)

Thus,

Actual Mean Cost of Running a Private Generating Set = 60.19 x 1000 Naira

Actual Mean Cost of Running a Private Generating Set = 60,190 Naira.

4.1.3 Cost Regression Analysis Results

After gathering of the costs involved in powering the five different cold rooms and analyzing the correlation between the costs by the spearman's correlation factor using visual basic developed software. The following results are given:

a) Calculation of Spearman's Correlation: Coefficient (R), For Coldroom 1.

Employing equation 2.4

$$r_s = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

The spearman's correlation coefficient (r_s) is been calculated using a Visual basic developed software. It uses the following parameters and their respective values obtained from the cost table, in computing the spearman's correlation coefficient:

i) Sum of x squared ($\sum x^2$),

ii) Sum of y squared ($\sum y^2$),

iii) Sum of xy ($\sum xy$).

The graphical user interface (GUI) is seen below.

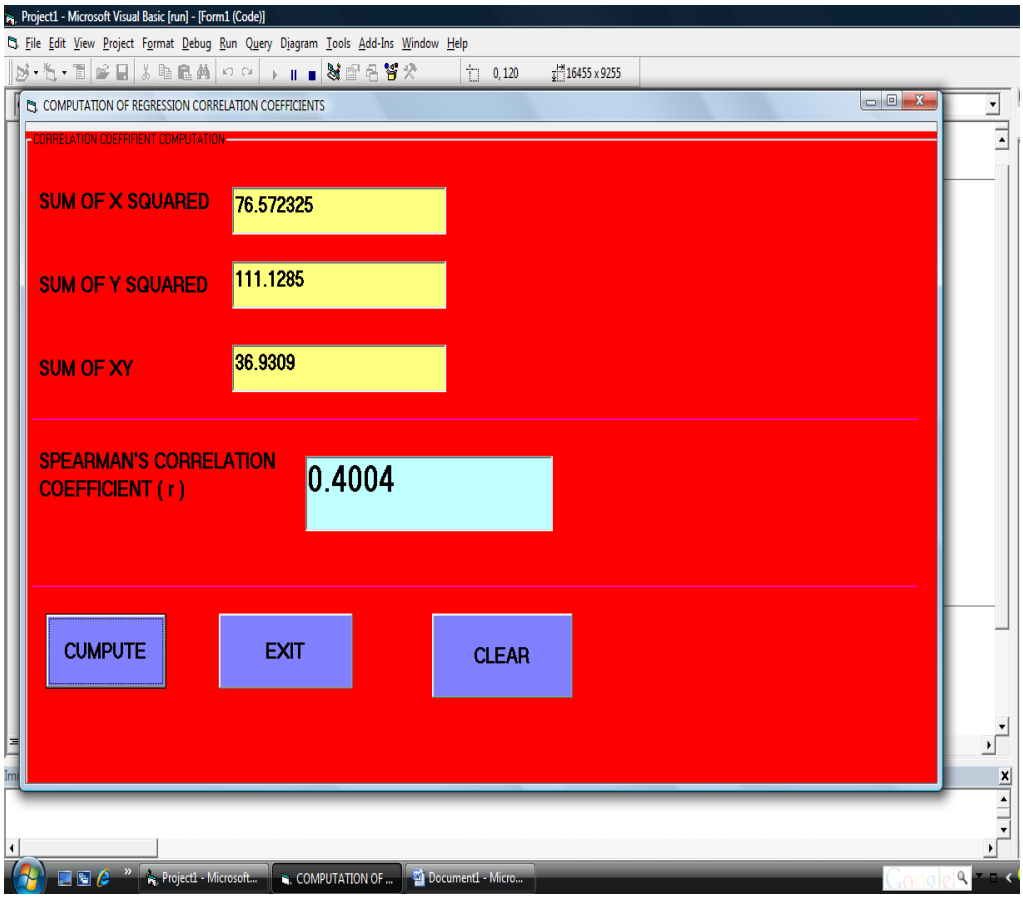

Figure 4.1: Visual Basic Graphical User Interface (GUI). For Calculating Spearman's Correlation Coefficient (r_s) of Cold Room 1.

From the Visual basic software developed for the computation of spearman's correlation coefficient (r), r = 0.4004 = 40.04%.

This entails that the correlation coefficient for the cost of paying PHCN bills over using a private power generating set is 40.04%, which means that the cost of running or maintaining a private power generating set is far much higher using power supplied from PHCN.

b) Calculation of Spearman's Correlation: Coefficient (R), For Cold room 2.

Employing equation 2.4

$$r_s = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

The spearman's correlation coefficient (r_s) is been calculated using a Visual basic developed software. It uses the following parameters and their respective values obtained from the cost table, in computing the spearman's correlation coefficient:

iv) Sum of x squared ($\sum x^2$),

v) Sum of y squared ($\sum y^2$),

vi) Sum of 5xy ($\sum xy$).

The graphical user interface (GUI) is seen below.

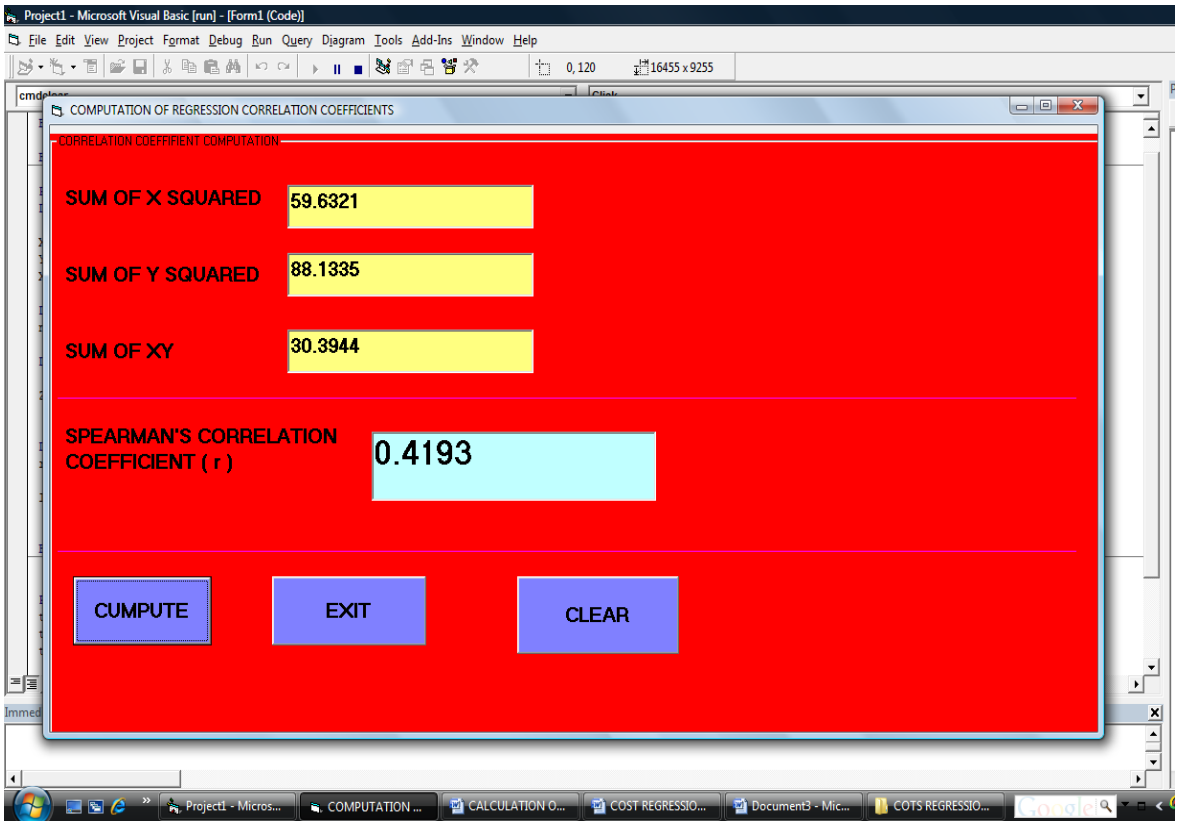

Figure 4.2: Visual Basic Graphical User Interface (GUI), for Calculating Spearman's Correlation Coefficient (r_s) of Cold Room 2.

From the Visual basic software developed for the computation of spearman's correlation coefficient (r), r = 0.4193 = 41.93%.

This means that the correlation coefficient for the cost of paying PHCN bills over using a private power generating set is 41.93%.

Henceforth, the cost of running or maintaining a private power generating set is far much higher than using power supplied from PHCN.

c) Calculation of Spearman's Correlation: Coefficient (R), For Cold room 3

Employing equation 2.4

$$r_s = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

The spearman's correlation coefficient (r_s) is been calculated using a Visual basic developed software. It uses the following parameters and their respective values obtained from the cost table, in computing the spearman's correlation coefficient:

i) Sum of x squared ($\sum x^2$),

ii) Sum of y squared ($\sum y^2$),

iii) Sum of xy ($\sum xy$).

The graphical user interface (GUI) is seen below.

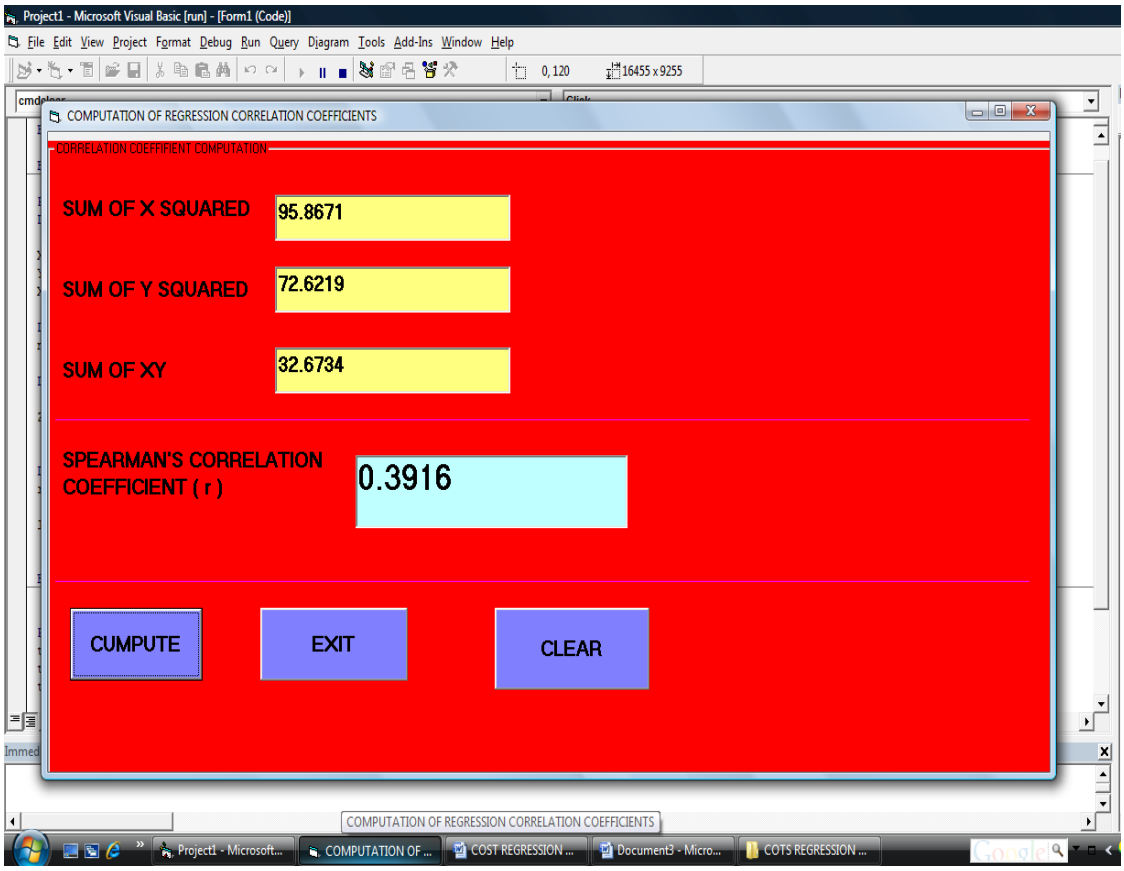

Figure 4.3: Visual Basic Graphical User Interface (GUI). For Calculating Spearman's Correlation Coefficient (r_s) Of Cold Room 3.

From the Visual basic software developed for the computation of spearman's correlation coefficient (r), r = 0.3916 = 39.16%.

This indicates that the correlation coefficient for the cost of paying PHCN bills over using a private power generating set is 39.16%.

Therefore, the cost of running or maintaining a private power generating set is far much higher than using power supplied from PHCN.

d)Calculation of Spearman's Correlation: Coefficient (R), For Cold room 4

Employing equation 2.4

$$r_s = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

The spearman's correlation coefficient (r_s) is been calculated using a Visual basic developed software. It uses the following parameters and their respective values obtained from the cost table, in computing the spearman's correlation coefficient:

i) Sum of x squared ($\sum x^2$),

ii) Sum of y squared ($\sum y^2$),

iii) Sum of xy ($\sum xy$).

The graphical user interface (GUI) is seen below.

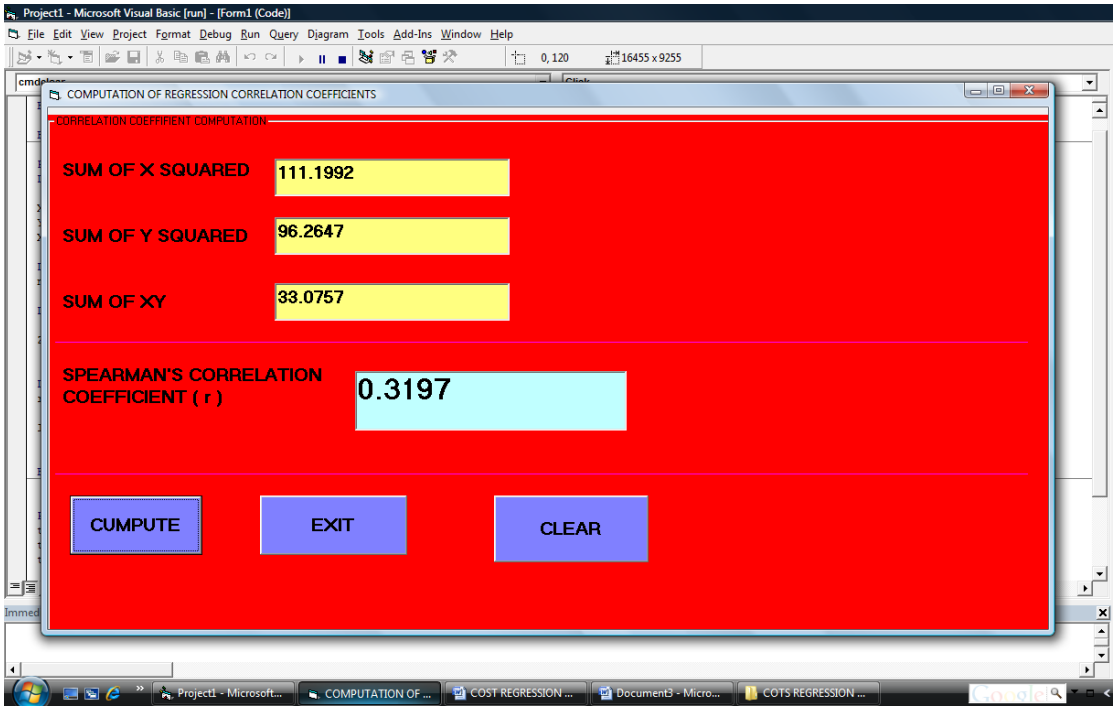

Figure 4.4: Visual Basic Graphical User Interface (GUI), For Calculating Spearman's Correlation Coefficient (r_s) Of Cold Room 4.

From the Visual basic software developed for the computation of spearman's correlation coefficient (r), r = 0.3197 = 31.97%.

This shows that the correlation coefficient for the cost of paying PHCN bills over using a private power generating set is 31.97%.

Thus, the cost of running or maintaining a private power generating set is far much higher than using power supplied from PHCN.

e)Calculation of Spearman's Correlation: Coefficient (R), For Cold room 5

Employing equation 2.4

$$r_s = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

The spearman's correlation coefficient (r_s) is been calculated using a Visual basic developed software. It uses the following parameters and their respective values obtained from the cost table, in computing the spearman's correlation coefficient:

i) Sum of x squared ($\sum x^2$),

ii) Sum of y squared ($\sum y^2$),

iii) Sum of xy ($\sum xy$).

The graphical user interface (GUI) is seen below.

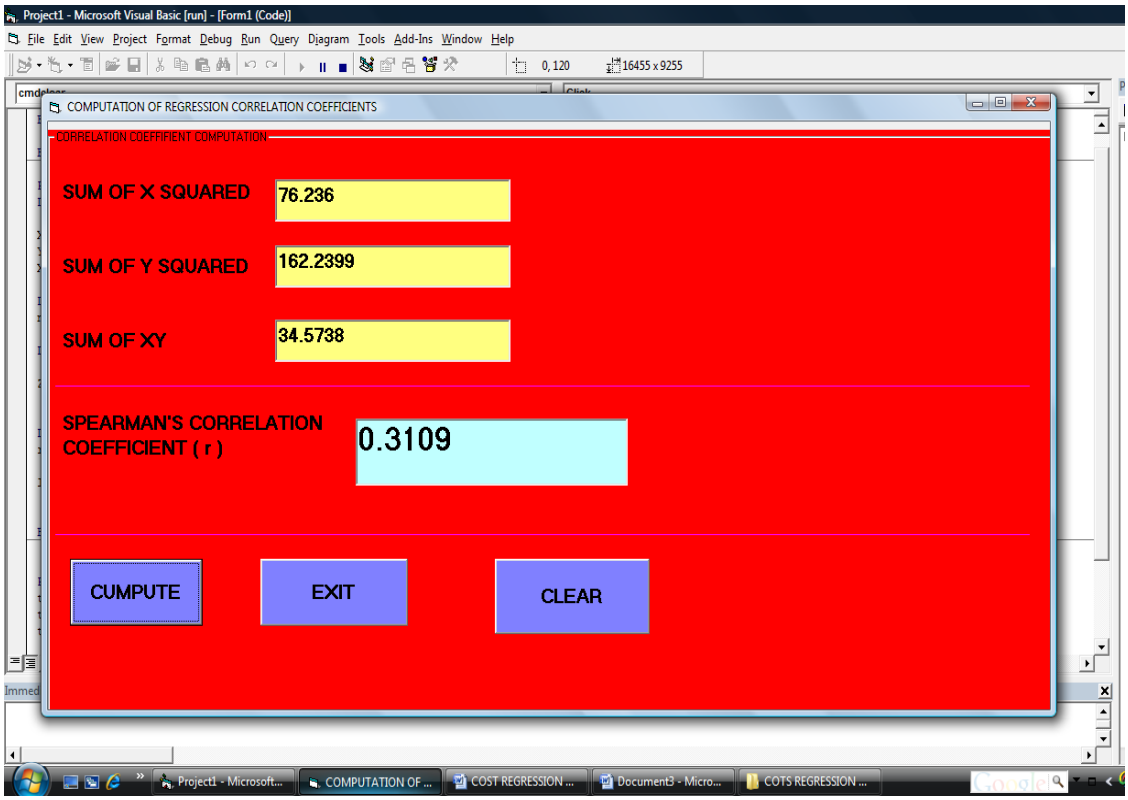

Figure 4.5: Visual Basic Graphical User Interface (GUI), For Calculating Spearman's Correlation Coefficient (r_s) Of Cold Room 5.

From the Visual basic software developed for the computation of spearman's correlation coefficient (r), r = 0.3109 = 31.09%.

This shows that the correlation coefficient for the cost of paying PHCN bills over using a private power generating set is 31.09%.

Hence, the cost of running or maintaining a private power generating set is far much higher than using power supplied from PHCN.

4.2 Discussions

Adequate supply and distribution of electricity constitute a main development issue, which cannot be over-emphasized. Apart from serving as the back bone or the pillar of wealth creation in our society, it is also the heart of operations and subsequently the 'engine of growth' for all the various sectors of our economy. In recognition of the consolidating linkages between the energy sector and the other sectors of the economy, electricity development and utilization, thus have pervasive impacts on a range of socio-economic activities and consequently the living standard of the citizens in our country.

This study assessed electrical power disturbance (outage) in Trans-Amadi District. The data employed for the study of power supply outages are data recorded from daily power supply outages and retrieved from the office of Power Holding Company of Nigeria. A Statistical model termed three-stage nested design with cross factors and replications was developed and applied to the power supply outages data gathered from the original daily entries logbooks of the Power Holding Company of Nigeria.

In order to be able to compare the cost differences in the utilization of power from PHCN supply and utilizing power obtained from a private generating set, five cold rooms were selected within the area under consideration. These cold rooms were chosen because the business of cold room management involves the effective use of electricity in the running of the day to day activities of its business.

As such, power outages from PHCN supply if not complemented with private power generating set will be of great adverse consequences to the business. The business of cold rooms is a very

sensitive and delicate one as it is all surrounded by perishable items, which requires adequate preservations.

4.2.1 Analysis of Customers Response

The objective of this work is to explore the impact of outages upon consumer sector in Trans-Amadi. Trans-Amadi is one of the largest city in Rivers State. The research tool used is shown in Appendix A.This research tool underwent an extensive developmental process. This involved aniterative approach consisting of the identification of factors to be included, designand development of the questionnaires and small scale testing of the questionnairesusing interviews with sample users. It was concluded that the actual experience approachis not feasible and that the questionnaire design could assist respondents in making reasonable predictions as to the degree of the effects and what their perceptionsand reactions might be.The data used in this study is based on 30 responses selected from 50 questionnaires.The selected survey involved samples of commercial consumers in Trans-Amadi.

The respondents were asked to provide information concerning their views towardsupply reliability, outages, occurrences, quality of service offered, degree ofhardship and discomfort as a result of service interruptions, the customer willingness-to-pay to avert an outage(s), impact of service interruptions at critical periodssuch as evenings and hot seasons where thepeak load normally occurs,their types of shops and their wages. All respondents inthe survey indicated that supply is unreliable with about 80% of the outages lasting for a long duration. Also, majority have agreed that the present tariff is not reasonable as they express the high cost of the monthly charge. Adirect estimate of outage costs was obtained by asking consumers to perceive thehardship and irritation of power outages and how much extra they would be willingto pay to avoid outages of different durations during summer time (questions 2 and3). Many consumers

indicated that, for outages within few minutes, no willingness topay and that they would sit out the inconvenience rather than to pay, and for outagesover one hour the tendency towards willingness to pay increases sharply as consumerswere willing to pay large sums of money, *i. e.*, the impact of outages upon the consumers*welfare* becomes substantial and intolerable (question4). The remaining questions (6-8) were mixed of attitudinal and demographic type ofquestions that seek information about the consumer, *i.e.*, his attitude about thestructure of current tariff, size and cost of electricity consumption, type of office space,net income etc.. After having verified the importance of this information,some are exhibited in the following sections.

4.2.2 Cost Estimation Based on Customer's Perception

Most of the outages effects, as noticed are intangible and cannot be assessed in terms of monetary values and a single complete measure of the worth ofreliability of supply to residential users is difficult if not impossible to obtain. The question which is appropriate to ask is: "What set of estimations should an analyst ora planner use as a criterion for reliability worth?" The answer depends on practicaland theoretical structure of the analyses. In general, it is the author's opinion thatone of the most suitable estimates of reliability worth is the customer's preparatoryactions during outages and his willingness-to-pay to avert their occurrences. This approachis practically sound and more related to the perception of the residential customerand to his energy requirements. To seek the customer's readiness and type ofpreparatory actions that he takes against system failure, respondents were' directedto suppose that they have been told by their power company that unexpected poweroutages will occur daily in dry season for various durations and asked to predictwhich action(s) they might take in preparation for the outages (Question 3). Thecosts quoted in the list of actions are used to compute an estimate of the cost of preparationsthat respondents indicate that they are willing to undertake to eliminate orat least to

mitigate the adverse effects of the outages. Also, the survey aims toexplore to what extent they are willing to pay to avert service cessation. Therefore, itis suggested (Question 4) that the power system has become subject to more frequentpower outages: To increase system reliability, the company may add generating unitsand/or reinforce its network facilities which may result in tariff increase. Hence, thequestion postulates daily power outages in dry period for durations of 20 minutes,1 hour, 4 hours, and 8 hours. A range of possible tariff rate increases is proposedand the respondents are asked to perceive and assess the possible damage resultingfrom service interruptions and consequently to discern the fair and appropriaterate increases based on the prevailing present tariff structure. The survey results show that a significant number of respondents were willing to pay higher rate for even up to 20% abovethe cost of the normal charge to avert prolong outage durations. The willingness-topay,however, becomes less when more rate increase is suggested or less frequentoutages are proposed.The cost per outage estimated as above are probably the most meaningful for theresidential user group but the cost/kWh and cost/kW are determined as well for comparisonwith other studies and for planning purposes. These are presented in Table 1and portrayed by Fig. 3. The Naira/kWh estimates were obtained by weighting the respondentmonthly "energy consumption and payment and converted to a per outagebasis to make the estimate consistent. The second part of the table lists the costs dividedby the estimated peak demand which was determined from the user's one yearconsumption history by assuming a prevailing load factor of 19%.

4.2.3 Standard Deviation Result

The standard deviation that was obtained in the distribution of power outages is 3.78 which is approximately 4 entails that there is high possibility of experiencing repeatable power outages, within the area under study. This can be obviously true as some of the time interval midpoints

are relatively low compared to the others and also from the uneven frequencies distributions of the power outages.

4.3 Regression Analysis of Results

After gathering of the costs involved in powering the five different cold rooms and analyzing the correlation between the costs using visual basic developed software, it is clear that the amount of money spent on operating cold rooms with a private power generating set is far much higher than power with electricity supplied from PHCN. These are seen in the spearman's correlation coefficients which were found to bear valuesof less than 0.5.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The importance of electricity to economic development of any nation cannot be over-emphasized. Access to reliable electricity supply increases the productivity and welfare of the society. Given the foregoing it suffices to say that poor electricity supply or lack of quality and effective electricity service delivery is a bane to economic development, it restricts economic growth and development as well as the socio-economic welfare of the people. Poor electricity supply affects business activities in many ways, as it affects productivity and causes damages to materials and machines as many raw materials and some finished products require constant flow of electricity for their storage, and any other cost would result in huge business loss.

From the analysis of the questionnaire as shown in Appendix A, one can draw a conclusion that most firms in Nigeria have developed strategies to cope with this poor electricity supply. Some of these response adjustments include: choice of business, choice of location, output reduction, factor substitution and self generation. While all these strategies are observable amongst Nigerian firms, the most commonly adopted strategy by firms is investment in alternative generation(i.e. complementary capital). Many electricity users both household and firms now find it necessary to make their generation in part or in whole to make up for the inadequate provision resulted from the inefficiency of the public power system. The result from the analysis shows that the cost of unsupplied kilowatt of electricity is significantly higher than the cost of electricity from the public grid using a spear man correlation factor by over 40%, of the cost on running on PHCN, with a standard deviation of 3.78 which is approximately 4 entails that there

is high possibility of experiencing repeatable power outages, within the area under study. This can be obviously true as some of the time interval midpoints are relatively low compared to the others and also from the uneven frequencies distributions of the power outages.

5.2 Recommendations

In the light of the study that has been conducted, discussion and conclusion reached above, the following recommendations are been suggested.

i. Power Holding Company of Nigeria should conduct a forecast of power demand trend within Port Harcourt and across the whole Nigeria. This will enhance the determination of the demand growth rate, so as to enable them carryout equipments and facility upgrades which will match the power supply to power demand with time.

ii. The government should embark on enormous capital investment across the electrical power chain (Generation, Transmission, Distribution and Sales) is required so as to encourage the Power Holding Company of Nigeria in meeting up with the society power supply demands.

iii. Improvement in generation capacity.

iv. Deliberate and sustained distribution network reinforcement/upgrade.

v. Enforcement of legislation against acts of vandalism on PHCN Installations.

vi. Mutual understanding between the power Supply Company and customers.

vii. Prompt payment of electricity bills.

viii. Comprehensive metering of customers.

ix. Human Capital Development

x. The current demand and supply imbalance can be corrected through additional power generation from the grid and Independent Power Project enhancement.

xi. Also for further studies, a survey can be carried out on the assessment of electrical power in other parts of the country so as to ascertain other areas that require attentions across transmission and distribution network.

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APPENDIX I

AHMADU BELLO UNIVERSITY ZARIA, NIGERIA

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTIONNAIRE ON THE COST OF PAYING PHCN BILLS AND COST OF RUNNING A PRIVATE GENERATING SET FOR COLD ROOMS OPERATION FOR A PERIOD OF 24 MONTHS.

Dear Respondent,

This is a questionnaire designed to obtain information on the cost of paying PHCN bills and the cost of running a private power generating set for the operation of cold rooms. It is structured to gather the information for 24 months. The information gathered will be used to analyze the correlation between the cost of paying PHCN bills and the cost of running a private power generating set for cold rooms operations.

Please do fill in the monetary amount you have spent per month in your cold room operations in terms of power utility for paying PHCN bills and also for operating with a private power generating set for a period of 24 months in the table below. This information is strictly for academic purpose only and will be treated with confidentiality.

Consumer Survey Questionnaire

1)Consumer's Experience with Supply Quality and Outages Occurrences during the Last Two Years

(a) How you rate (encircle one) electric service quality (0 inadequate-6 Excellent)?

0 1 2 3 4 5 6

(b) How many outages occurred?

(One_____ two_____ three_____ four_____more_____

(c) How many times outages exceeded?

20min____ 1 hour____ 4hours_____ 8 hours_____ 24 hours_____

2) Losses resulting from Lasting Outages and Certain Preparatory Actions

This question explores certain preparatory actions taken by the consumer as outages occur and last forlonger durations. These actions attempt to mitigate the effects of outages. The lists of possible preparatory actions are:

a). Make no preparations and live up with outages.

c) Use a gas refrigerator or freezer to keep meat and fish fresh

c) Use private generating sets.

Now chose and circle the appropriate preparatory action(s) as listed above that you may take to lessenthe effects of the outages if they last for the following durations:

20min a b c

1hour a b c

4hours a b c

8 hours a b c

3) This question seeks consumer's opinion concerning the cost of electricity versus power outages. So, it proposes range of possible percentage increases in the present tariff that the consumer is willing to pay for different outage durations (encircle the appropriate %) :

Daily outage duration	**% tariff increase**					
20 min	5	10	20	30	40	50
1 hour	5	10	20	30	40	50
4 hours	5	10	20	30	40	50
8 hours	5	10	20	30	40	50

4) Electric Tariff and Energy Consumption

(a) Indicate what you think about the present electric tariff:

Low reasonable high

(b) What was your average monthly electricity consumption and charges (only during summer season):

_____ (kWh/mo) _____(Naira/mo)

5) Cost of running compared with private generating source and PHCN

Months	**Cost Of Operating With Power Supply From Phcn.**	**Monthly Cost For Diesel, Utilized In Powering A Private Generating Set.**	**Maintenance Cost Of The Private Generating Set.**	**Total Cost Of Operating With Power From A Private Power Generating Set.**
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				

15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				

APPENDIX II

VISUAL BASIC CODES USED FOR THE DEVELOPMENT OF THE SOFTWARE FOR THE COMPUTATION OF SPEARMAN'S CORRELATION COFFICIENTS OF THE COSTS OF RUNNING COLD ROOMS.

```
Private Sub cmdexit_Click()

End

End Sub

Private Sub cmdcompute_Click()

Dim X As Double, Y As Double, XY As Double

X = Val(Me.txtX.Text)

Y = Val(Me.txtY.Text)

XY = Val(Me.txtXY.Text)

Dim numerator As Double

numerator = XY

Dim denominator As Double, Z As Double

Z = X * Y
```

```
denominator = Z ^ (1 / 2)

 Dim r As Double

r = numerator / denominator

lblr.Caption = Format(r, "0.0000")

End Sub

Private Sub cmdclear_Click()

txtX.Text = ""

txtY.Text = ""

txtXY.Text = ""

Me.lblr.Caption = ""

End Sub
```