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Influence of ideal equipment maintenance practice on the reliability of power supply at the Port of Mombasa

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Abstract

The purpose of the study was to establish the influence of ideal equipment maintenance practice on the reliability of power supply at the Port of Mombasa. The study adopted a descriptive research design using both quantitative and qualitative approaches. The sample size comprised of 203 respondents with data collected through questionnaires. Findings showed that management of Kenya Ports Authority (KPA) updates the existing power supply equipment regularly. This shows that KPA had initiated the power upgrade to solve the problem of the unreliable power supply at the port. From the results, it is notable that KPA equipment maintenance policy is ISO certified. The port has implemented the Integrated Security System for the port in order to make the port compliant as per the International Ship and Port Facility System (ISPS). Additionally, KPA undertakes both corrective maintenance and preventive maintenance of equipment.. Moreover, KPA engineers usually undergo refresher courses on equipment maintenance policy. This is an indicator that KPA is geared towards ideal practices of maintaining of power equipment. This in effect has led to reliable supply of power at the port. Correlation analysis established that ideal equipment maintenance practice had a positive and significantly relationship with reliability of power supply at the Port of Mombasa. The study concluded that ideal equipment maintenance practice has a significant influence on reliability of power supply at the Port of Mombasa. The recommendation was that the management of the Kenya Ports Authority in Mombasa should continuously carry out efficient process on maintenance of newly upgraded equipment at the port to guarantee future reliability of power supply.

Keywords: *Ideal equipment maintenance practice, Reliability of power supply*

1.1 Introduction

For a nation to enjoy economic growth, it is requisite for it to have consistent, reliable power supply. Energy sector in developing countries faces many challenges be they technical, financial or managerial in nature. This calls for rapid response and special attention. For there to be efficient and sustainable solutions to engineering and management problems facing the power sector it is not possible to do without carrying out analysis of factors both technical and managerial that are behind the challenges the sector faces in its entirety (Zhu, 2014). Problem around reliability of power supply in developing countries are not influenced by the same factors as those in developed countries. Considering these differences, it is almost impossible to achieve efficiency in in economic development through following related energy restructuring programmes in emerging economies (Oricha & Olarinoye, 2012).

Unreliability of electricity supply due to imprudent of equipment maintenance practices and the high cost of the same provide a great challenge for economic growth of low-income countries as compared to economically powerful countries. Cost and time allocated to acquiring power in Less Developed Countries (LCD) is much higher than that of High-income countries (HICs). The biggest challenge to economic empowerment for developing countries is unreliability and high tariffs of power supply. Studies done in Ghana showed that unreliable power supply due to unreliable equipment maintenance practices was costing the local industries over US $686.4 million in sales per year (Beck & Robert, 2014). Countries in Sub Saharan Africa have electricity generating and transmitting equipment that in most cases employ old technology that is inefficient (Zhu, 2014).

The KPA is the body recognized by law and formed by an act of parliament responsible for the operation and management of port operations in the coastal town of Kenya, Mombasa. The port is fully equipped and highly modernized. The port core functions include: provision of marine services, cargo handling, ships dockage, other land based ancillary services in inland cargo depots (KPA, 2012). In Kenya, unscheduled power interruptions and unreliable electricity generation and transmission equipment maintenance practices have been a cause of major disruptions to the Port of Mombasa operations with adverse effects. Power outages or surges have led to tripping out of the electrically driven cranes such as the ship to shore gantry cranes leading to unnecessary down-times for the cranes and staff, hence reduction in the throughput targets for the Port.

These power supplies interruptions affects the on-line automation system with documents processing being suspended as most are computer-based and the losses are in millions of shillings (KPA, 2012). The resultant slow-down of cargo handling has adverse implications to National and Regional cargo transfer. While the port has implemented the Integrated Security System (ISS) for the port to make the port compliant as per the International Ship and Port Facility System (ISPS), interruptions to power supplies renders the security systems vulnerable to unacceptable down-times leading to security compromises (KPA, 2012). Power surges are also reported to damage the sensors, cameras, servers leading to surveillance lapses and the KPA facility being vulnerable to un-authorized intrusion. Biometric clocking also fails, and manual entry has to be initiated which in addition to being a security risk also leads to industrial disputes due to workers being unable to account adequately for any over-time worked. Lack of reliable surveillance system also more than often leads to pilferage of cargo, materials and vehicle parts from the port. The integrity of port security is largely dependent on how power supply is reliable (KPA, 2012).

The port operations have been affected by unreliability of power supply due to unreliable equipment maintenance practices leading to numerous power interruptions. Initially, the port was being supplied at 11 kilovolt level and was sharing the power network with surrounding customers at Shimanzi and there were numerous power outages with adverse negative effects on port operations. Kenya Ports Authority undertook a power upgrade project at the port of Mombasa to mitigate negative effects of erratic power supply from Kenya Power and Lighting Co Ltd (KPLC) in August 2012. The project was completed in December 2014. The scope of work entailed the construction of a new substation and connection of the port power system to the dedicated supply on the national grid at 132 kilovolt level (KPA, 2016). The project has led to uninterrupted electrical power supply to the port with power outages minimized from a frequency of approximately five outages per month to approximately five outages per year. Only national outages now affect port operations. This study aimed at analyzing the relationship between ideal equipment maintenance practice and reliability of power supply at the port of Mombasa.

1.2 Statement of the Problem

Due to intermittent power supply at the port of Mombasa, KPA commissioned an internal analysis of the existing grid power system to assess its long-term effect on the reliability of power supply to the organization (KPA Strategic Plan, 2010). Performance gaps were identified through analysis of existing system data, reports and in-depth interactive interviews of various stakeholders. There was need for improvement in distribution, development and maintenance of the grid power supply. It was observed that these intermittent voltage dips on various occasions resulted into damage to equipment used for the port Integrated Security System (ISS) and also controls for the cranes causing excessive crane down-times and compromise to the port security among other non-compliances (KPA Strategic Plan, 2010). To mitigate on the unreliability of power supply at the Port of Mombasa, KPA undertook a power upgrade project at the port of Mombasa in August 2012. The project was completed in December 2014. Since the completion of the project, few studies focusing on the relationship between ideal equipment maintenance practice and reliability of power supply at the port of Mombasa have been conducted. This being the situation, it was worthwhile to conduct this study to bridge the existing study gap.

1.3 Objectives of the study

The general objective of the study was to establish the influence of ideal equipment maintenance practice on the reliability of power supply at the Port of Mombasa.

1.4 Research Hypothesis

H_{01}: Ideal equipment maintenance practice has no statistical significance on reliability of power supply at the Port of Mombasa.

2.0. Literature Review

2.1. Theoretical Review

2.2.1. Resource Dependence Theory (RDT)

This theory was developed by Pfeffer and Salancik (1978). The theory looks at how an organization's dependency on external resources affects its behavior. External resources include raw materials, power and labor. For this study, external resources are mainly electric power maintenance equipment that Kenya Ports Authority uses from Kenya Power. RDT explains the changes that happen to an organization's behavior depending on the situations surrounding the external resources they rely on to survive. Availability or lack of it of the external resources influences how an organization operates. This is notable from reduction in electricity interruptions at the port of Mombasa resulting from injection of ideal electric equipment maintenance practices.

The study focuses on Kenya ports Authority as an industry and ideal equipment maintenance practice, supplied by an external resource which is the Kenya Power company. KPA does not have any other sources of electricity other than from Kenya Power hence its insistence on ideal equipment maintenance practice for reliable power supply. Power supply form Kenya Power was initially erratic hence the necessity of the power upgrade project. There are three bases for RDT according to Pfeffer and Salancik (1978). One, the survival of firms rests on its ability to acquire and retain critical external resources. The critical resource in this case is ideal equipment maintenance practice from Kenya Power. The second pillar of the theory is that there is no organization that has full control of all the resources it requires hence need for external resources. In this case, KPA has to rely on Kenya power for ideal equipment maintenance practice. Thirdly, RDT does not identify reliance on external resources as a problem for the firm but rather when the resources are not available reliably, then a problem presents. An organization hence needs to come up with strategies to cope with the unreliability. KPA had to initiate the ideal equipment maintenance practice with Kenya Power for reliability of power supply at the port to be achieved. Unreliable power supply at KPA made it necessary to initiate a project called Mombasa power upgrade project as a means of coping.

RDT further states that if external resources are extremely unreliable yet crucial for the organization's survival, they may force the collapse of the organization. For the organization to be able to survival under such conditions it must reduce its reliance on those resources. An organization can reduce its dependency external resources by increasing their power over the resource. This could be done by gaining as much control as possible over that resource. KPA opted to go for upgrade of power project to mitigate erratic power supply from Kenya Power. KPA decided to alter its internal structure by ensuring dependability of ideal equipment maintenance practice and adjust to external environment as outlined in RDT theory to survive. Therefore, the theory is relevant and applicable in this study.

2.2. Empirical Review

Maintenance of power system is aimed at reducing failure and negative consequences that could be realized in industrial, commercial or domestic sectors out of it. Maintenance is either break down or preventive maintenance. Preventive maintenance purposes to replace components at pre-determined durations while condition-based maintenance is done after monitoring the condition of the systems (Kerzner, 2011). It is necessary for the decision maker to identify the right maintenance policy based on each component or equipment. This will enable the managers to avoid replacing components before they are optimally utilized, maintain consistent and stable power supply, and avoid overstaying components already beyond their utility (Brinckerhoff, 2013).

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Akaranga (2014) attempted to establish the factors affecting customer satisfaction through adequate equipment maintenance practices with Kenya Power and the objectives were: to establish the influence of reliability of power supply on customer satisfaction with Kenya Power Company in Nairobi County, to establish the influence of cost of electricity on customer satisfaction with Kenya Power Company in Nairobi County and to establish the influence of innovation of new equipment and products on customer satisfaction with Kenya Power Company in Nairobi County. The research design used was descriptive research method. The instruments of data collection were questionnaires. The findings of the research were that the respondents were dissatisfied with the services provided by Kenya Power Company. The customers were not aware of some of its innovations because the communication techniques used were not effective. The customers also complained of lack of reliability of power supply and high cost of electricity due to poor equipment maintenance. Although this study was on customer satisfaction at KPLC, it has not focused on the KPA upgrade project at the port of Mombasa like in the current study.

Burlando (2010) examined how unreliability of power affects growth of SMEs in Kumasi Ghana. Poor power supply has been given as a major impediment for growth of SMEs in Ghana. The unreliability of power and its high tariffs eat significantly in to the SMEs profits. The study concluded that unreliability of power supply negatively affects SME's performance in Ghana while increasing operation costs. This study is in Ghana, a country and its focus was on SMEs growth and power insecurity while the current study is on reliability of power at the port of Mombasa.

2.3. Conceptual Framework

The conceptual framework is based on the relationship between equipment maintenance practices in terms of corrective and preventive maintenance measures may improve and reliability of electricity supply at the port of Mombasa in terms of customer satisfaction and frequency of interruptions. Therefore, the relationship between ideal equipment maintenance practices and reliability of power supply at the Port of Mombasa is indicated.

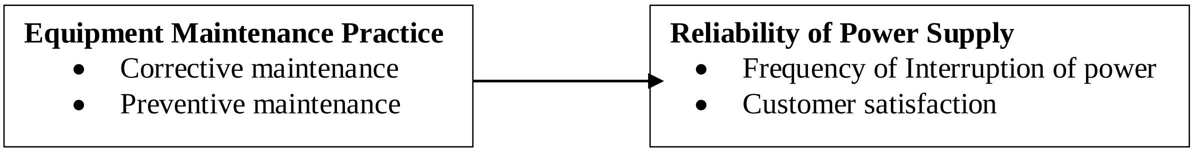

Figure 1: Conceptual Framework

3.0. Research Methodology

This study adopted a descriptive research design using both quantitative and qualitative approaches. Quantitative approach was utilized aiming at quantifying the hypothesized association between variables. The descriptive design focused on gathering information about the influence of the Mombasa power upgrade project on the reliability of power supply at the Port of Mombasa. This design was used because the target population consisted of various categories of power experts who were instrumental in providing information. The target population comprised of employees of six departments of Kenya Ports Authority based within Mombasa. The management and unionsable employees formed the target population. There were 428 management and unionsable employees.

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The first step in sampling in this study involved the use of stratified random sampling, followed by proportionate stratified sampling to select six strata of the six departments at Kenya Ports Authority. Further, to constitute the sample size, the researcher used simple random sampling technique. The overall sample size comprised of 203 respondents. The study used a questionnaire administered to each member of the sample population. Pilot study was carried out among six departments at the Kenya Ports Authority, with respondents in the pilot study excluded in the main study. Data analysis used descriptive and inferential statistical methods using Statistical Package for Social Sciences (SPSS) and results presented through percentages, means, standard deviations and frequencies.

Regression model used was as follows;

$$\mathbf{Y=\propto+\beta_1 X_1+\varepsilon_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Y= Reliability of Power Supply

$\propto$=Constant

B_{ij} = regression coefficients

X_1= Ideal Equipment Maintenance

ε_0 =Error term

4.0. Results and Discussion

4.1.1. Bi-variate Linear Relationship between Study Variables

Before running regression analysis, researcher tested correlational matrix to establish whether association existed between ideal equipment maintenance practices and reliability of power supply as shown in Table 1.

Table 1: Linear relationships of variables

		Ideal Equipment Maintenance Practice	Reliability of power supply
Ideal Equipment Maintenance Practice	Pearson Correlation	1	.533**
	Sig. (2-tailed)		.000
	N	150	150
Reliability of Power Supply	Pearson Correlation	.498**	1
	Sig. (2-tailed)	.000	
	N	150	150

**. Correlation is significant at the 0.01 level (2-tailed)

The study results revealed that ideal equipment maintenance practice was positively and significantly associated reliability of power supply at the Port of Mombasa. (r = 0.533, p<0.05). The correlations were significant at the level of significance of 0.05. The results implied that increasing ideal equipment maintenance practice would lead to increase in reliability of power supply.

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4.2. Diagnostic Tests

4.2.1. Multicollinearity

This study carried out a test for multicollinearity by computing the variance inflation factors (VIF) and its reciprocal, tolerance. Multicollinearity was performed on the data by examining VIF (variance inflation factor) and assessing the tolerance (1/VIF). Independent variables are considered collinear if the value of VIF exceeds 3. Table 2 presents VIF values that was 1.781 implying that multicollinearity was not a problem in the data.

Table 2: Multicollinearity

		Collinearity Statistics	
Model		**Tolerance**	**VIF**
1	(Constant)		
	Ideal Equipment Maintenance Practice	.582	1.718

a. Dependent Variable: Reliability of Power Supply

4.3. Factor Analysis

Factor analysis was carried out before analysis of the results to describe variability among the observed and check for any correlation with the aim of reducing data that was found redundant.

4.3.1. Factor Analysis on Ideal Equipment Maintenance Practices

Exploratory factor analysis was used to refine the constructs. The results showed that Kaiser Meyer-Olin Measure of Sampling Adequacy) KMO Measures of Sampling Adequacy of manifest variables was 0.920 which was above the threshold of 0.6 and p-values for Bartlett's test of Sphericity (χ^2 =2654.753, p=0.00) was significant (below 0.05). This implies that data was adequate to run factor analysis and correlation patterns were close thus factor analysis would yield reliable and stable results. The results are shown in Table 3.

Table 3: Factor analysis

Statistic		**Value**
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.920
	Approx. Chi-Square	2654.753
Bartlett's Test of Sphericity	Df	325
	Sig.	.000

4.3.2. Homoscedastic Test

The study used Breusch-Pagan and Koenker test to estimate heteroscedasticity. The results present significant values more than 0.05 indicating that heteroscedasticity was not a problem as presented in Table 4.

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Table 4: Test of Homogeneity of Variances

	LM	Sig
BP	.738	.390
Koenker	.774	.379

Null hypothesis: heteroscedasticity not present (homoscedasticity)
If sig-value less than 0.05, reject the null hypothesis

4.3.3. Normality test using Kolmogorov-Smirnov test

Skewness and kurtosis are used to measure normality test as presented in Table 6. Normality of the variable is assumed if its skewness and kurtosis have values between the range of -1.0 and + 1.0. All the items in the study measured values of skewness and kurtosis between 1 and -1. Thus, normality was realized.

Table 6: Kolmogorov-Smirnov Test of Normality

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Ideal Equipment Maintenance Practice	150	.734	.198	.622	.394
Reliability of Power Supply	150	.455	.198	-.128	.394

4.4. Influence of Ideal Equipment Maintenance Practices on Reliability of Power Supply

The study conducted univariate regression analysis to test the relationship between ideal equipment maintenance practices and reliability of power supply when other factors are held constant.

4.4.1. H_{a1}: Ideal equipment maintenance practices has no statistical significance on reliability of power supply

a) Ideal Equipment Maintenance Practices on Reliability of Power Supply

The findings of the model summary indicated that, R^2 realized 0.750 indicating existence of strong association of ideal equipment maintenance practice and reliability of power supply at the Port of Mombasa. The findings demonstrated that ideal equipment maintenance practice shares a variation of 75.0 % of reliability of power supply at the Port of Mombasa. These results are shown in Table 8.

Table 8: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.866[a]	.750	.743	.41325

a. Predictors: (Constant), Ideal Equipment Maintenance Practice

b) Ideal Equipment Maintenance Practices on Reliability of Power Supply ANOVA

The findings of ANOVA showed F-value=108.568 and p-value of 0.000<0.05 which indicated that the model used to link ideal equipment maintenance practices and reliability of

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power supply had a goodness of fit. Therefore ideal equipment maintenance practices significantly predicted reliability of power supply. The results are shown in Table 9.

Table 9: ANOVA of ideal equipment maintenance practices

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	74.164	4	18.541	108.568	.000[b]
1	Residual	24.763	145	.171		
	Total	98.927	149			

a. Dependent Variable: Reliability of Power Supply
b. Predictors: (Constant), Ideal Equipment Maintenance Practices

c) Regression Coefficients of Ideal Equipment Maintenance Practices

The findings show the regression coefficient weight for ideal equipment maintenance practice was positive and significant (β= 0.284, t= 4.118, p< .05). Therefore, the null hypothesis was rejected at p<0.05 level of significance implying that ideal equipment maintenance practice has a significant influence on reliability of power supply at the Port of Mombasa. The regression estimate for ideal equipment maintenance practice was 0.284; this indicates that a unit increase in ideal equipment maintenance practice would result in 28.4% increase in reliability of power supply at the Port of Mombasa. These results are shown in Table 10.

Table 10: Regression coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	.217	.029		7.531	.000
	Ideal Equipment Maintenance Practice	.284	.069	.273	4.118	.000

a. Dependent Variable: Reliability of Power Supply

4.5. Hypotheses Testing

The testing was done based on the findings of multiple regression analysis and was tested at the level of significance of 0.05.

$H_{A1:}$ Ideal equipment maintenance practice has no statistical significance influence on the reliability of power supply at the Port of Mombasa.

The study sought to test the research hypothesis that ideal equipment maintenance practices has no significant influence on the reliability of power supply at the Port of Mombasa. The regression analysis showed that ideal equipment maintenance practices had a beta coefficient of 0.284 with a corresponding p-value of 0.000; meaning ideal equipment maintenance practices had a positive and significant determination on reliability of power supply at the Port of Mombasa. Based on these finding the study rejected $H_{A1:}$ ideal equipment maintenance practice has no statistical significance influence on the reliability of power supply at the Port of Mombasa. This finding agrees with Akaranga (2014) who revealed that regular maintenance of power equipment is crucial for supply of reliable power for industrial growth.

5.0 Conclusions

The study aimed at identifying the influence of ideal equipment maintenance practice on the reliability of power supply at the Port of Mombasa. Through correlation analysis, ideal equipment maintenance practice had the third best prediction of reliability of power supply. Further, the regression weight for ideal equipment maintenance practice was positive and significant. Therefore, the null hypothesis was rejected at $p<0.05$ level of significance. The study concluded that ideal equipment maintenance practice has a significant influence on reliability of power supply at the Port of Mombasa.

6.0 Recommendations

The study established that ideal equipment maintenance practice had a positive and significant association with reliability of power supply at the Port of Mombasa This is an indicator that systematic maintenance of the power generation and transmission infrastructure is essential for reliable power supply. Therefore, the study recommended that the management of the Kenya Ports Authority in Mombasa should continuously carry out efficient process on maintenance of newly upgraded equipment at the port to guarantee future reliability of power supply.

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