MAINTENANCE MANAGEMENT PRACTICES AND OPERATIONAL PERFORMANCE IN ELECTRICITY PRODUCING STATIONS IN KENYA

BY

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DECLARATION

This research project is my original work and to the best of my knowledge, it has not been presented for award of degree in any other university or college for academic purposes.

Signed…………………………………… Date……………………

Kamau Julius Mwangi

D61/73864/2009

This research project has been submitted for examination with my approval as the University supervisor.

Signed…………………………………… Date……………………

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DEDICATION

I honestly and truly dedicate this Project work to my Lord God, my Creator, this far my good Heavenly Father has brought me. Without his true mercies, grace and care, this work could not have come to completion. Glory be to Him always.

ACKNOWLEDGEMENT

I wish to acknowledge the true dedication and commitment given to this Project work by Dr. Njihia, my project supervisor. With his guidance, what seemed insurmountable and laughable became truly a wonderful master piece. The hope and guidance he gave me, honestly can never pass un-noticed.

To my wife Rebecca, my son Andy Victor and daughter Grace-Anne, I salute you. You were truly a great inspiration to this work. You were there for me, when I needed your support, prayers and understanding.

To my fellow students, thank so much for all the good times were shared together. The information shared and hopes given to each other were truly inspiring and worthy to appreciate.

Lastly but not least, I thank all the great men and women of the stations which were under study, for sparing their valuable time to acknowledge and fill the truly lengthy Questionnaire. God bless you all.

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LIST OF ABBREVIATIONS

BM:	Breakdown Maintenance
CBM:	Condition Based Maintenance
CMMS:	Computer Maintenance Management System
ERC:	Energy Regulatory Commission
ERP:	Enterprise Resource Program
g :	gram
IPPs:	Independent power producers
Kg:	Kilogram
KenGen:	Kenya Electricity Generating Company Limited
KPI:	Key performance indicator
Kshs:	Kenya Shillings
Kwh:	Kilo watt hour
MM:	Maintenance Management
MTTF:	Mean Time To Failure
MTTR:	Mean Time To Repair
Mw:	Mega Watt
OEE:	Overall Equipment Efficiency
PCDA:	Plan Correct Develop and Act
PM:	Preventive Maintenance
PPA:	Power purchase agreement
PDM:	Predictive Maintenance
QM:	Quality maintenance
RBV:	Resource Based View
RCM:	Reliability Centered Maintenance
RTFM:	Run to failure Maintenance
SAP:	System Application program
TPM:	Total Productive Maintenance
VRIN:	Valuable Rare In-imitable Non-substitutable

ABSTRACT

The study was entitled 'Maintenance Management Practices and Operational Performance in Electricity Producing Stations in Kenya'. The overall objective of the study was to determine how the extent of application of maintenance management practices and management support impact on the operational performance on the stations which generate electricity in Kenya. The specific objectives of the study were: To establish the extent of application of the various maintenance management practices and to establish the level of top management support in maintenance management, Further, it sought to determine the impact of the adopted maintenance management practices on operational performance and to establish the challenges faced in maintenance management in the electricity producing stations in Kenya.

The statement of the problem has explained why the study was necessary. This was because there was a maintenance management jungle which had not been solved hence the need of this study. The jungle relates to lack of universally accepted maintenance management practice (s), contradicting theories and lack of clear cut information relating to costs of maintenance, challenges and impact of human factor on operational performance. The various maintenance management practices have been outlined and discussed. Further, theories that are applicable to maintenance management have been discussed and linked to maintenance management practices. A summary of the literature review and maintenance management conceptual framework have been provided.

The research methodology used was descriptive cross sectional survey design. The data, collected by mean of a questionnaire was analyzed by measures of central tendency and simple regression analysis through graphs drawn using Microsoft excel. The extent of application of maintenance management practices, level of top management support and challenges encountered in maintenance management were ranked in percentages and displayed by means of bar graphs. To determine the relationship between operational performance and maintenance management practices and management support, regression analysis using SPSS (Statistical package for social sciences) was used. The developed model was found to be insignificant since the p value obtained was above 0.05 at the adopted 95% confidence level.

The findings of the study were that; maintenance costs were high in relation to the organization total running costs at 15 to 33 % and at an average of 27%. The study further found that there was no one particular practice which was largely applied in relation to the others. However broadly, preventive maintenance practices were largely been applied than reactive maintenance. The study found out that the level of top management support for maintenance management was low. This was causing a decline effect on operational performance. Further, it was observed that the extent of application of maintenance management practices had a positive impact on operational performance. Inadequate training of maintenance personnel, spares acquisition procedures and delay in delivery of spares were the greatest challenges encountered in the stations producing electricity in Kenya.

The study concluded that, maintenance costs are higher in stations producing electricity. Further, there seems to be other factors which affect operational performance which need to be determined. The study limitations were time, below 60% response level and scope of the study. The value of the study was that it generated both theoretical and practical maintenance knowledge. This knowledge can be used by maintenance professionals and those charged with maintenance activities to improve maintenance management practices hence productivity of their stations.

CHAPTER ONE: INTRODUCTION

1.1 Background

In Kenya, electrical power is a major production input. Without adequate electrical power, industrial growth and economic activities in Kenya would be affected. Such a scenario would make foreign investors look for other countries with adequate electrical power supply and do business there. Therefore, the electricity producing stations in Kenya play a crucial role in the growth of the country's economy and in industrial growth.

To support the industries and their growth, therefore, the electricity generating stations are supposed to keep their electricity generating machines running throughout and in particular maintain a certain PPA set point of above 85% availability (PPA, 2006). However, this sometimes become difficult to achieve because machines breakdown normally occurs. Also, the machines need to undergo routine maintenance so as to keep them in good running and reliable conditions (Smith, 2003). It therefore means that, electricity producing stations must manage their maintenance practices strategically so as to achieve their operational objectives and obligations.

1.1.1 Maintenance Management and Operational Performance

According to Al-Turki (2011), maintenance management are the activities of planning, organizing, implementing, monitoring and controlling in order to sustain a certain level of availability, value and reliability of the system and its components (assets) and its ability to operate to a certain standard level of quality. Therefore, the choice of the maintenance management practice applied impacts heavily on the performance of the firm. The main measures of operational performance of a firm are reliability, maintainability, productivity, efficiency, availability and production per unit cost, among others (Wilson, 2002). Since Firm's maintenance costs are normally high (Al-Turki, 2011) application of best maintenance management practices can boost a firm's operational performance (Gupta et al., 2005). The maintenance management practices which offer better operational performance therefore need to be established in research.

1.1.2 Management Support

One factor normally overlooked by organizations in pursuit of their operational success is the human factor in operational performance (Gupta et al., 2011). Hipkin and Cock (2000) asserted that management support is the tipping board between operational success and failure. In the RBV theory, Danny (2003) noted that, the skills imparted to the human resource in a firm goes to a great extent to award the firm competitive advantage. Clearly then, an organization should properly blend optimal maintenance management practices and management support for continuous improvement for it to survive in the current competitive operational arena (Gupta et al., 2011).

1.1.3 Electricity Producing Stations in Kenya

In Kenya, there are several electricity producing stations. These stations produce the electrical power needed to operate industrial machines and equipment and for domestic uses and also for lighting. The stations generate electricity either by means of kinetic energy of flowing non-seasonal rivers' water, diesel driven engines, wind turbines, gas turbines or from underground steam. Stations which produce electricity from water are called hydro power stations. Diesel power stations utilizes diesel driven Engines while the stations producing electricity from underground steam are referred as geothermal power stations. The common aim is usually to drive the generators, the equipment which generates electrical power when rotated.

According to Kenya investment Prospectus (2013-2016), the total electrical power produced by these stations is about 1,664 Mw. Due to transmission and distribution system weaknesses, the suppressed national electrical power demand is 1,356 Mw against a national unsuppressed demand of 1,700 Mw. There is therefore a shortfall of 536 Mw after providing for a 30% reserve margin recommended by National Economic and Social Council (NESC). There is therefore a challenge of electrical power supply-demand imbalance in the country.

The major electricity producer in the Country with 25 Stations is KenGen. KenGen generates about 1240 Mw of the electrical power in the Country which is equivalent to about 75 % of the Country's power supply (KenGen website, 2014). The rest of the electrical power (25%) is produced by IPPs. These are Or Power, Tsavo Power, Rabai Power and Thika Power Company (ERC website, 2014). These stations and their capacities are as listed in Appendix 2.

The stations are required to be running through out since there is electrical power supply shortfall in the country (Kenya investment Prospectus, 2013-2016). Therefore, the stations are under very tight production schedules with limited timeliness to undertake their routine maintenance and repairs. The costs of this maintenance are normally high (Cross, 1998 & Al-Turki, 2011). Further, the spare parts needed for the repairs are mostly gotten from overseas. The procurement procedures and the distance from the source markets most of the times lead to delayed spares' deliveries. Therefore, these stations must adopt strategic maintenance management practices to overcome the challenges involved and to ensure that they maintain a specific availability otherwise they end up paying huge fines to Kenya Power, their sole customer (PPA, 2006).

1.2 Statement of the Problem

The maintenance management practices that a firm adopts, impact heavily on its operational performance (Gupta & Marquez, 2006). A firm must hence adopt practices which offer it operational success (Campell, 1995).There are many maintenance management practices in use in electricity producing stations in Kenya. The problem of the Kenyan firms is that, they have not adopted these practices fully to their advantage due to technological challenges and mainly due to tight production schedules (Njoroge, 2010).

Electricity producing Stations in Kenya are under obligation from Kenya Power, their main customer, to maintain a minimum running availability of their stations of above 85%. They therefore need to adopt the best maintenance management practices which will enable them meet this objective at optimal maintenance cost. The adopted maintenance management practices ought also to reduce the Firms' maintenance costs which have been estimated by past Scholars as very high at 25% of the total organization running costs Cross (1998), others put it at 30 % (Al-Turki, 2011), while others as 2 to 10 % (Smith, 2003). The adopted strategies should also enable the Firm meets its other target objectives and world class status of over 90% availability and performance efficiency of over 95% (Douglas, 2012).

To achieve the firm's set objectives, optimum maintenance management practices need to be adopted, ensuing challenges dealt with and the organization performance indicators need to be monitored so as to implement improvement actions (Gupta & Marquez, 2006). However Ahmed and Duffaa (1995) had argued that, there is no universally accepted maintenance methodology for designing a maintenance system yet some maintenance practices have been known to result to higher overall cost reductions than others (Marquez & Gupta, 2006). Danny (2003) and Barney (1991) also conflicted as to which one between tangible or intangible assets offers firms' operational practices a competitive advantage. Marquez et al., (2006) also noted that, the human factor in maintenance had been ignored and its impact needs to be ascertained.

The above foregoing has led to confusion and conflict with no clear guideline as to which is the best maintenance management practice (s). This has lead to the maintenance management jungle (Smith, 2003) which needs to be addressed in research. Similar local studies by Ngatia (2013), Mulwa (2000) and Malaki (2013) did not solve this jungle. A research question them crops up: how do the maintenance management practices and level of management support impact on the firm's operational performance despite the challenges that are encountered?

1.3 Research Objectives

1.3.1 General Objective

The study seeks to establish how the extent of adoption of maintenance management practices and level of management support in the various stations which produce electricity in Kenya impact on the organizational performance.

1.3.2 Specific Objectives

The Specific objectives of the study shall be:

i) To establish the extent of application of the various maintenance management practices by the various electricity producing stations in Kenya.

ii) To establish the level of top management support in maintenance management in the electricity producing stations in Kenya

iii) To determine the impact of the adopted maintenance management practices on the organization's operational performance.

iv) To establish the challenges faced in maintenance management in the electricity producing stations in Kenya.

1.4 Value of the Study

The study generated both theoretical and practical maintenance knowledge which can be used by maintenance professionals and those charged with maintenance activities in improving maintenance management practices hence productivity of the stations. In particular, those who will benefit are top management of the electricity producers, maintenance officers and scholars aspiring to do more research in maintenance management.

For the top management of the Stations, they will get to gauge their performance against those of similar stations producing electricity. In particular, they will get to know their weaknesses as far as maintenance management in their Stations is concerned and hence determine actions plans for improvement.

Maintenance officers, charged with the responsibility of managing maintenance in their Stations will benefit the most. As direct beneficiaries, they will determine where they need to change strategy so as to improve maintenance activities in their stations as far as measures and achievement of high maintenance performance are concerned.

Lastly and not least, Scholars aspiring to do more research in maintenance management can use this study as a baseline for their work. The literature review and the findings of this study will enable this group of beneficiaries to find research gaps to enhance their areas of study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Marquez and Gupta (2006), defined maintenance management as the activities of management that determine maintenance objectives or priorities, strategies and responsibilities and implement them by means such maintenance planning, maintenance control and supervision and several improving methods including economical aspects in the organization. Marquez and Gupta (2006) go further to regard maintenance management as a process and also as a framework. As a framework, they noted that it is the essential supporting structure and the basic system needed to manage maintenance effectively. As a process, it is the course of action and the series of steps or stages to be followed.

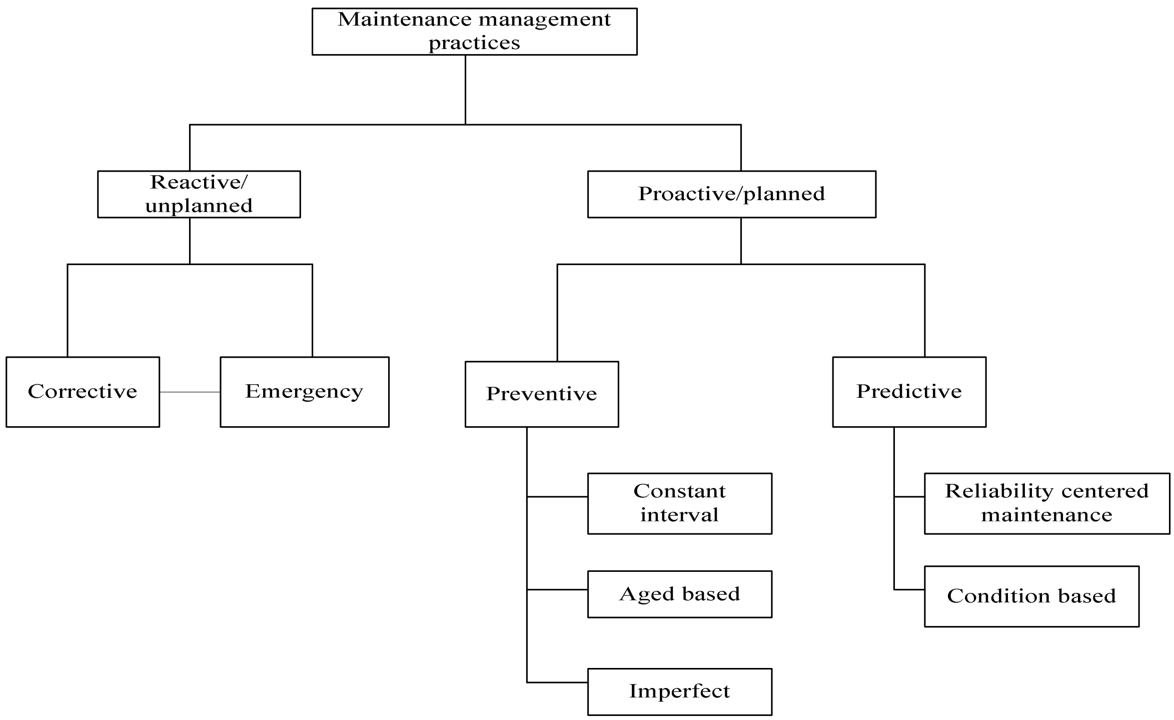
As observed by past researchers, maintenance costs are usually 10 to 30% of an organization's total running costs. This costs can be minimized by adopting well known maintenance management practices / concepts and by monitoring performance of the Firm through measures of the Firms key performance indicators (KPI's) (Simoes et al., 2011). This is meant to ensure that the Firm's objectives are been meet and where failure to meet the objective exists; intervening actions need to be taken **(**Vanneste & Wassenhove, 1995). If managed properly, maintenance can be a profit generator and if mismanaged, it can leads to Firms making huge losses.

According to Alsyouf (2007), in recent years, managers are warming to the idea that maintenance can be a profit generating function rather than a cost centre. It is therefore clear that maintenance management plays a vital role in an organization. Maintenance management therefore seeks to avoid production disruptions, minimize productions costs because production capacity is available when needed (Palmer, 1999), maintain high quality of products and the manufacturing machinery and to avoid missed deliveries (Vagliasidni, 1989).

2.2 Maintenance Management Practices

There are various maintenance management practices (Veldman, J., Wortmann, H., & Klingenberg W., 2011 and Al-Turki, 2011). Organizations need to strategically choose the best maintenance management practices which offer them the best operational performance (Marquez & Gupta, 2006). Accordingly to Veldman et al., (2011), maintenance management practices can generally be classified into two i.e. unplanned and planned maintenance as per the figure 2.1 below.

Figure 2.1 Classification of maintenance management practices



Adapted from; Veldman, Wortmann, & Klingenberg (2011).Methodology and Theory: Typology of condition based maintenance. *Journal of Quality in Maintenance Engineering, 17*(2), 183- 202

According to Marquez and Gupta (2005) there are nine-(9) maintenance management approaches. These are run to failure, redundancy, scheduled replacement, scheduled overhauls/planned, adhoc/ unplanned maintenance, preventive maintenance (PM), age or use based maintenance, and condition based maintenance (CBM) and re-design/design improvement. While this classification by Marquez and Gupta (2005) is somehow similar to the classification by Veldman et al., (2011) it introduces run to failure, redundancy, scheduled and predictive maintenance management practices. The above maintenance management practices are discussed below has follows:

2.2.1 Condition Based Maintenance

CBM is the maintenance which is normally done when operating conditions deviate from the norm. It is done to detect incipient failures long before they occur (Veldman et al., 2011). It uses condition monitoring techniques to determine whether a problem exists in running equipment and for how long the equipment can operate before failure. This maintenance management practice detects and identify specific components in an equipment that are degrading, determine root cause of the problem and take remedial actions before failure of the equipment or operating asset (Tsang et al., 1999).

2.2.2 Productive Maintenance

Productive maintenance is the practice of taking small scale repairs/ remedial actions by operations staff when the equipment is still in operation. When all the employees of an organization are involved in such repairs actions, this is termed as total productive maintenance (TPM). TPM involves predicting occurrence of failure and fostering active involvement in maintenance by production workers rather than separate maintenance workers. Its goals are zero breakdowns and zero defects (Gupta et al., 2005). TPM emphasizes operator involvement in routine maintenance.

2.2.3 Reliability Centered Maintenance

RCM is the maintenance done based on probability of equipment failing and cost of such failure. RCM allows detection of failures long before they occur to ensure minimum interruptions to the production process. It also eliminate occurrence of failures before they show up (Marquez et al., 2009). According to Ngatia (2013), RCM is the process of determining and ensuring that any asset continues to operate as expected under its present condition. It is a prioritized maintenance practice to first carry maintenance to assets with high risk value in terms of safety and economics. Marquez et al., (2009) identified RCM as maintenance a practice which was gaining global importance.

2.2.4 Preventive Maintenance (PM)

PM is a planned or schedule maintenance that is done on the onset of failure to prevent or delay breakdowns and to minimize the impact of a breakdown (Wild, 2002). This maintenance management practice is based on the principle that prevention is better than cure. It consists of maintenance activities performed before equipment breaks down with the intent of keeping it operating acceptably to reduce likelihood of failure (Dilworth, 1992). The advantages of this practice are that it reduces rate of breakdowns, increases asset availability, maintain optimum efficiency of the equipment and reduces workload on maintenance staff. PM also increases productivity and safety of the workers (Murthy, 2005).

2.2.5 Scheduled Maintenance

This is preventive maintenance which is normally done at scheduled intervals to improve reliability of a machine and deal with any hidden potential of failure. Scheduled maintenance is a replacement of corrective maintenance when maintenance practices change from reactive to proactive (Smith, 2003). Scheduled maintenance is a stitch-in-time maintenance aimed at avoiding breakdown (Murthy, 2005).

2.2.6 Quality Maintenance

This type of maintenance management is also called ‘tune up’ or production improvement maintenance. This maintenance management practice involves stopping a production machine to attend to defects or to bottlenecks that may be hindering the production asset to perform to its maximum capacity. It is aimed at increasing the production efficiency (Khan & Darrab, 2010).

2.2.7 System Work Orders Maintenance

This is the type of maintenance management practice which is executed as a result of a computer generated maintenance work orders. The principle of this maintenance management practice is based on Computer Maintenance Management System (CMMS). System work orders maintenance is the backbone of proactive maintenance. It is the primary tool for managing labour and measuring effectiveness (Smith, 2003). It triggers appropriately prioritized tasks, manages maintenance resources and allows proper monitoring and control of assets. It is mostly used where the number of items to be maintained is high and the complexity of the plant is high (Marquez & Gupta, 2005).

2.2.8 Run to Failure' Maintenance (RTFM)

In run to failure maintenance, the unit is operated without any preventive maintenance until failure occurs. It is when failure occurs that maintenance is done on the equipment. According to Khan and Darrab (2010), RTFM is the done when increase in maintenance and quality hours' maintenance no longer translates to increase in production (see Figure 2.3).

2.2.9 Breakdown Maintenance

This is a type of unplanned or reactive maintenance which is normally done when a breakdown has actually occurred (Pannerrselvam, 2009). It is done to restore an asset to its previous operating condition. When reactive maintenance is done to restore the equipment to its original condition this is called corrective maintenance. When reactive maintenance is done to prevent a hazardous occurrence, it is called emergency maintenance (Veldman et al., 2011). Breakdown maintenance is not a recommended maintenance practice. This practice reduces productivity and is more costly than other maintenance management practices (Murthy, 2005).

2.2.10 Age/Time Based Maintenance

Age based maintenance is done at a specified time interval Marquez and Gupta (2006). This kind of maintenance may be done on daily, weekly, monthly, quarterly, semi-annually or yearly basis and is also referred as time based maintenance (Murthy, 2005). According to Smith (2003), time based maintenance is a preventive maintenance which is normally done at scheduled intervals to improve reliability of a machine and deal with any hidden potential of failure.

2.2.11 Predictive Maintenance

PDM is a condition based maintenance which manages trends values. It measures and analyses data about deterioration and employs surveillance technology designed to monitor running conditions of an asset through an on-line system. When conditions deviate from norm, remedial maintenance actions are taken (Pannerrselvam, 2009). PDM is based on sensing that equipment is going to give trouble e.g. if noise and vibrations have increased and thus prior arrangements for repairs are done. In PDM, troubles are predicted before the equipment fails. Remedial measures are therefore executed and this extends the service life of equipment (Murthy, 2013).

2.2.12 Imperfect Maintenance

Imperfect maintenance is the type of maintenance done to bring back the equipment to operation but not as good as new. A maintenance concept of bringing back equipment to as good as new condition is called perfect maintenance (Smith, 2003).

2.2.13 Redundancy Maintenance

This type of maintenance management practices is also called stand-by capacity maintenance. Stand-by capacity is often provided for the items of equipment that are critical for production. In case of one unit failing, the stand-by machine is brought into operation as the defective machine is repaired (Murthy, 2013).

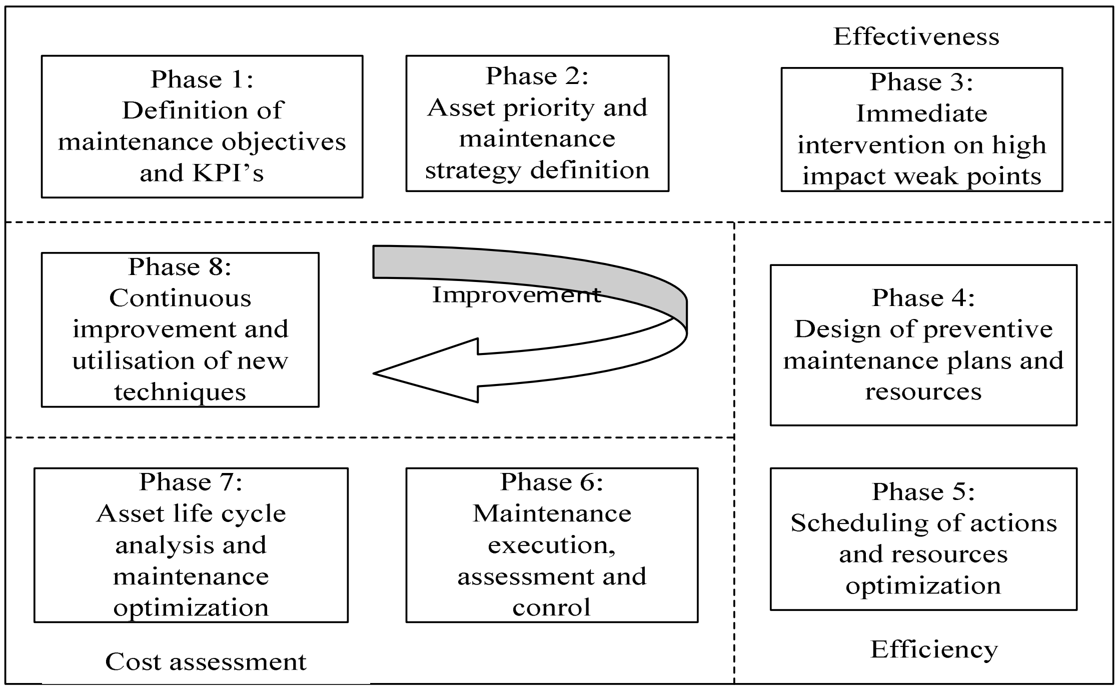
2.2.14 Scheduled Replacement Maintenance

When a production machine is stopped because of a failure of a part, the failed part is normally replaced. A decision may be made that, similar parts/equipment which have been in operation the same time period as the failed part, also need to be replaced. The assumption is that the parts installed the same time as the failed parts are likely to fail in future. Thus, scheduled replacement maintenance is adopted in such a case (Wild, 2002). Scheduled replacement maintenance is also opted for low cost items whenever convenient especially if their maintenance costs are high than the cost of replacing them (Naylor, 1996).

2.3 Maintenance Management Framework

Vanneste and Wassenhove (1995) proposed an approach to maintenance management that assesses the maintenance management (MM) process as effectiveness analysis of detecting the most important problems and locating their potential solutions. They also proposed the use of efficiency analysis i.e. identifying the suitable procedures to adopt in MM. According to Murthy (2005), the efficiency and effectiveness of a maintenance practice can be measured by four dimensions namely cost, quality, dependability and reliability, as measures of operational performance. Further, Marquez et al., (2009) asserts that operational objectives and performance measures need to be consistent to the declared overall business strategy. To this end, they proposed a generic model for managing maintenance consisting of eight sequential phases as shown in Figure 2.2 below.

Figure 2.2 Maintenance Management Frame-work



Adapted from Marquez et al., (2009).

Vanneste and Van Wassenhove (1995) noted that, when these phases are completed, one may need to go back to phase one to take further efficiencies. This in the spirit of Deming's PDCA cycle, as it would work in practice (Marquez & Gupta, 2005).

Hassanain et al., (2001) also presented a generic framework consisting of five-(5) sequential maintenance management steps as; identifying the asset to be maintained, identifying its performance requirement, assessing the asset's current performance, planning for the asset's maintenance and managing the maintenance operations. However, Marquez and Gupta (2005) noted that a variety of considerations, data, polices, techniques and tools affect the effective execution of maintenance. The importance of the maintenance management framework is that it provides guidance inform of steps in which to carry out and manage maintenance of assets.

2.4 Operational Performance

Gupta and Marquez (2005), asserts that, for an organization to be operationally successful, it must increase its productivity and minimize its costs. Mulwa (2000) notes that, for a firm to succeed, it must adopt efficient and effective production processes monitor and continuously improve those processes. Therefore the production costs of an organization must be minimized while at the same time increasing its productivity, capacity, reliability and availability (Al-Turki 2011).

According to Sharma and Yadava (2011), organizations are now adopting maintenance management as a profit generating business element. Manufacturing system are now operating more efficiently, effectively and economically to sustain their long term survival. Daya and Duffaa (1995) noted that maintenance can be viewed as a value adding activity instead of a necessary evil of expenses. Al-sultan and Duffuaa (1995) suggested that maintenance controls should be enhanced in order to achieve maintenance optimization. Sharma and Yadava (2011) noted that the best maintenance optimization practice is the one which considers maintenance policy, cost and reliability measures.

Wilson (2002) identified the some business processes which should be used for optimizing operational performance. These are: minimizing maintenance costs, maximizing profitability of production by adopting optimal maintenance practices/concepts to reduce maintenance costs, maximizing plant utilization and capability and retaining high asset value, maximizing performance efficiency and maximizing work safety at economic cost. Further, Ben- Daya et al., (2000) also identified equipment availability as a measure of a Firm's operational success. Eti et al., (2005) also noted that reduction of failure rate can be a measure of optimized maintenance. Marseguerra et al., (2002) also noted that reliability as a measure of optimized maintenance management should determine the level of preventive maintenance required.

2.5 Maintenance Management and Operational Performance

According to Komomen (2002), maintenance related costs in manufacturing organizations, are estimated at 25% of the overall operating costs. According to Al-Turki (2011), the maintenance costs of modern manufacturing and construction Companies are normally high at 30% of the

Firm’s total running costs. Parida and Al-Turki (2006) estimated that this cost is more in electrical power producing companies. It is therefore important that close attention should be made to maintenance measures, measurement and management in order to reduce organizational operational costs, improve the organizational efficiency and effectiveness.

According to Parida and Al-Turki (2006), the important factors in implementation of maintenance performance measurement and management are; measuring the value created by maintenance, justifying investment, revising resource allocations, health, safety and environmental issues, focusing on knowledge management and adapting to new trends in operation and maintenance management. Therefore maintenance performance must be enhanced through proper maintenance measurement and management so as to ensure organization success.

According to Gomes et al., (2011), the most used maintenance performance measurements are; technical, economic, safety and human resources. They noted that the least utilized measures were: training/learning, skills/competencies, work incentives, process performance, resource utilization, maintenance capacity, customer satisfaction and employee satisfaction. Further, Gomes et al., (2011) noted that, whereas cost is an importance measure, future research should also focus on deriving practical measures aimed at capturing the human factor of the maintenance performance effort. They did a research and found out that the most used maintenance measures in order of most used to least used were as follows:

Table 2.1: Maintenance Measures in order of Most Used to Least Used

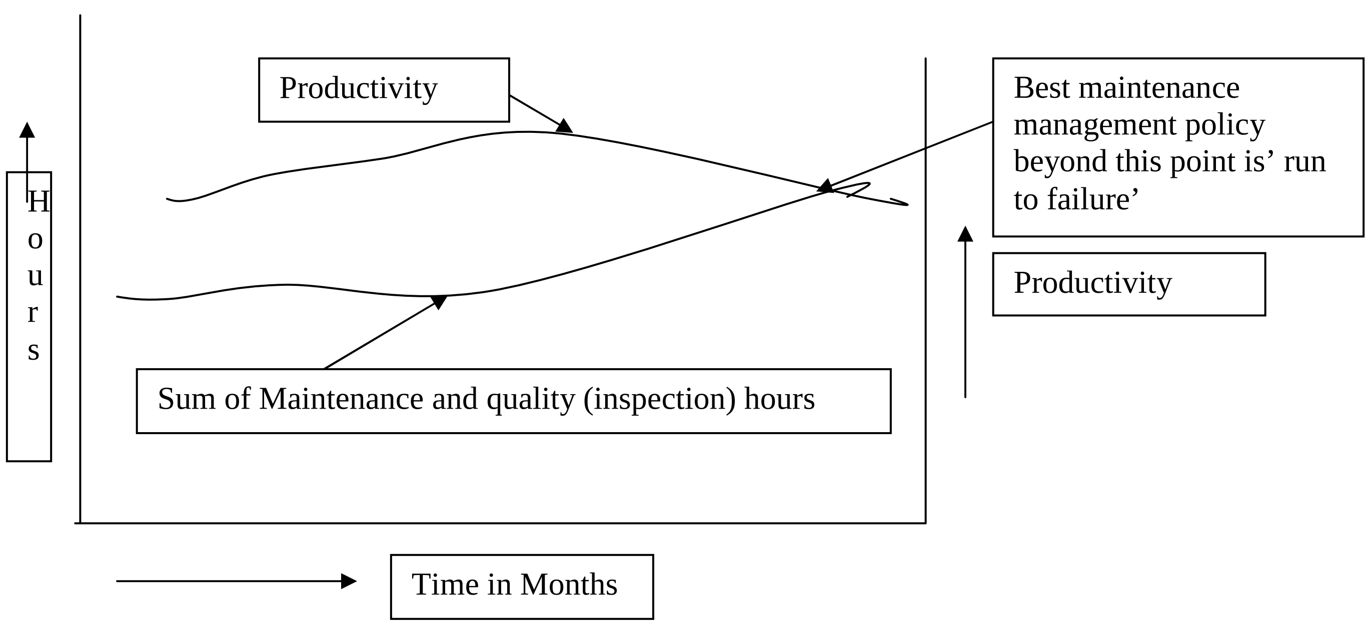
1)	Cost	20)	Downtime cost
2)	Overall equipment effectiveness	21)	Defect
3)	Availability	22)	Labour cost
4)	Quality	23)	Equipment losses
5)	Mean time before failure	24)	Accidents
6)	Tasks/jobs activities	25)	Work orders
7)	Mean time to repair	26)	Tools
8)	Materials	27)	Time
9)	Equipment	28)	Service level
10)	Downtime	29)	Man power
11)	Labour	30)	Inventory cost
12)	Failures frequency/rate	31)	Mean time to failure
13)	Reliability	32)	Flexibility
14)	Productivity	33)	Events/occurrences/counts
15)	Spares parts	34)	Efficiency
16)	Maintenance strategies/types	35)	Cycle time (Delivery)
17)	Human resources	36)	Breakdowns
18)	Planned maintenance	37)	Breakdown maintenance
19)	Maintenance organization		

Source: Adapted from Simoes et al., (2011): Emerald Science Direct, inform World and Springer Link

The above data is based on research carried out based on 156 articles. It is with this regard that Marquez and Gupta (2005) noted that maintenance, quality and productivity are companions, not trade-offs. They noted that quality and production can be enhanced if overall equipment effectiveness is improved through proper and adequate maintenance of machinery and equipment. They further stated that productivity tells how well maintenance, quality and production systems as a whole are performing.

Using data from sweets manufacturing plant, Khan and Darrab (2010) were able to show that, as maintenance hours increased, the productivity increased due to reduced breakdowns. However, as some point, they noted that increasing maintenance level further only increased productions costs at a reduced productivity. Beyond this point, they noted 'run to failure' was the best practice (Figure 2.3). According to Marquez and Gupta (2005), the best maintenance practice which enhances a firm to meet its global objectives need to be selected.

Figure 2.3: Demonstration that as Maintenance Level Increases, Productivity Increases only to Some Point.



Source: Adapted from Khan and Darrab (2010)

2.6 Top Management Support

The human factor in maintenance management has been ignored. Management support for this resource is vital to operational success and if is lacking organizations' operations may be extremely costly in terms of low productivity and products being out of quality (Gupta & Marquez, 2005). According to Armstrong (2000) there should be high level support from managers aimed at eliciting a commitment from the workforce so that the behavior of the workforce is mainly self-regulated. Armstrong (2000) went ahead to assert that, competitive advantage is attained by developing core competencies in the workforce. Such development of competencies should include training of workforce, rewards systems and provision of the required resources to perform the work so as to enhance operational success of a Firm.

The job of a manager is to have work done through people. Therefore, he/she should induce people to work to the best of their ability (Mills, Standingford & Appleby, 1986). According to Hannequin and Arango (2009), for total productive maintenance and total quality maintenance to work towards the advantage of the firm, great investments in human and information resources are required. However, Al-Turki (2011) noted that top management support for maintenance management is seldom since maintenance is not considered a strategic function. The necessity for top management support for maintenance management should be backed by figures and analysis to show how it can offer organizations high operational performance (Al-Turki ,2011).

2.7 Challenges of Maintenance Management

Maintenance Management (MM) is frequently associated with a wide range of difficulties (Marquez and Gupta, 2005). Marquez and Gupta (2005), attributes the difficulty in MM to lack of MM models that could improve the understanding of the underlying dimensions of Maintenance. Visser (1998) further argues that, a body of knowledge is lacking to clearly guide maintenance management. This led to difficulty in decisions making as to which maintenance delivery strategy to adopt (Marquez & Gupta, 2005).

According to Marquez et al., (2005), maintenance is composed of a set of activities for which is very difficult to find procedures and information support systems in one place to ease the improvement process. Hipkin and De Cock (2000), present a ranking of barriers in the implementing maintenance systems. They ranked the barriers faced by managers, supervisors and operators in maintenance management as : lack of plant and process knowledge, lack of historical data, lack of time to complete the analysis required, lack of top management support and fear of disruptions in productions and operations.

Marquez and Gupta (2005) further noted that the increase in automation and reduction of buffers of inventory have clearly put pressure on the maintenance system. Electricity power cannot be inventoried and therefore this pressure is more in service and utility firms like power producers than in manufacturing Firms. Further, Buchanan and Besant (1985) noted that, in highly automated Plants, the limitations of computer controls, the integrated nature of the equipment and the increase of knowledge requirements make it difficult to diagnose and solve equipment problems.

As already noted by several researchers, maintenance costs are normally very high. Cost issue is truly a challenge to maintenance management. Further, according to Hannequin and Arango (2009) some maintenance management practices such as total productive maintenance and total quality maintenance require great investments in human and information resources. Many enterprises may not have the required funds for these investments. It is also notable that top management support for maintenance management practices in organizations is seldom since maintenance is wrongly regarded as being a non-strategic function (Al-Turki, 2011)

2.8 Theoretical Perspective of Maintenance Management and Performance

There are several existing theories which can be linked to maintenance management as observed from the content of Literature review. These theories are Systems Theory, Resource Based Theory, Theory of constraints and Transaction costs theory. These theories in perspective of maintenance management are as briefly discussed below.

The Systems theory views systems as inputs/output models. The inputs are taken through process (es) to transform them to outputs. The outputs are compared with the objectives and feedback is send to the inputs to enhance improvement of efficiency and productivity of the system (Ludwig, 1968). The concept of this theory was applied in maintenance management by Visser (1998) as in Figure 2.4. He noted that maintenance management being the system, the inputs were labour, materials, spares, tools, information and external services. The maintenance system processed these inputs into availability, maintainability, safety and profits as the outputs.

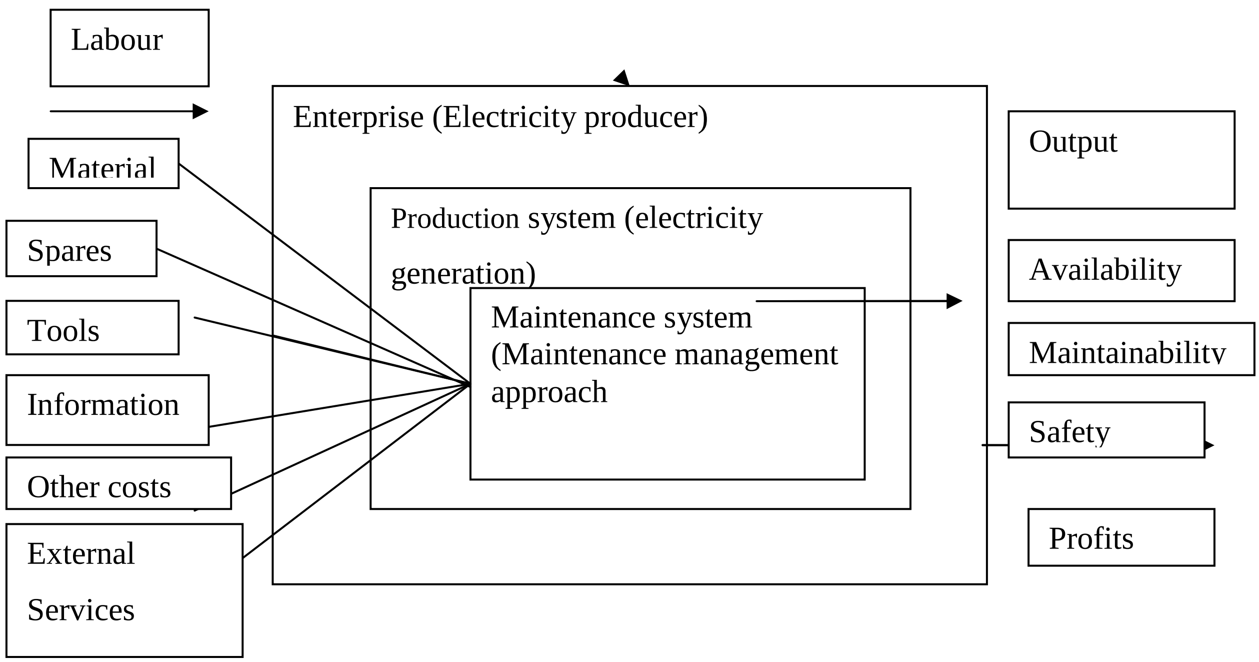
The Theory of constraints is applicable to activities meant to improve organizations. It consists of problem solving management decisions making tools called thinking processes meant to identify and eliminating system constraints. It answers the questions; what is to change, to what to change and how to cause the change (Eliyahu, 1984). In the same regard, maintenance management needs to be improved by identifying the processes which need to change and to what to change to and the procedures of causing and adopting the change (Douglas, 2010), so as to improve the maintenance management practices .The theory goes ahead to assert that the goal of a firm should be to maximize profits by increasing output, reducing inventory and reducing operating costs. Applying this theory therefore, if properly handled, maintenance management can enhance the achievement of the objectives of electricity producing firms in Kenya.

The other theory which can be applied in maintenance management is the RBV theory. The theory paraphrased stipulates that, for a firm to excel in its area of operation with competition from other firms, its resources must have competitive advantage (Barney, 1991). Barney noted that such resources should have some characteristics, denoted as VRIN. This means the resources should be value adding, rare, in-imitable and non-substitutable by competitors. However, Danny (2003) countered Barney theory and asserted that competitive advantage does not depend so much on resources but on intangible assets as skills, processes or assets which a firm cannot cost. Gomes et al., (2011) had also noted such assets were less used as measures of maintenance performance.

Finally but not least, the Transaction cost theory postulates that, a firm exists because of its capacity to economize on the costs of its market oriented production (Slater & Spencer, 2000). This means that, production costs need to be reduced for a firm to succeed in the chosen market. Slater & Spencer (2000) noted that efficiency advantages of any organization are greatest where long term contracts are negotiated including employment issues (Coase, 1937). Applied to maintenance management, this theory agrees that, production costs (in this study case;

maintenance costs) need to be reduced for an organization to enhance its performance (Al-Turki, 2011). Further, long time contracts in spares supply, repairs and operation contracts and also maintenance staff deployment need to be for the long run not for short term.

Figure 2.4: Maintenance Management as an Input /Output System



Source: Adapted from Al-Turki, A. (2011). Methodology and Theory: A framework for strategic planning in maintenance. ***Journal of Quality in Maintenance Engineering.***

2.8 Summary of Literature Review and Research Gap

Various approaches to maintenance management have been identified by past Researchers. However, the classifications of these approaches are not uniform across the board. Some approaches identified by some researchers have been identified by other Researchers as sub-set of other methodologies. However, Veldman et al., (2011) noted that all maintenance approaches are either reactive (unplanned) or proactive (planned). However, there is no one particular approach identified as the best. However, RCM and CBM have been identified as gaining global popularity (Marquez & Gupta, 2005)

Most Researchers agree that, the maintenance costs contribute to a huge portion of the total running costs of any organization. Further, they concur that, maintenance costs of any organization needs to be minimized for enhanced profitability of the firm. Hennequin and Arango (2009) state it clearly that the optimal maintenance management practice is the one which reduces maintenance costs, keeps the equipment in a satisfactory operating condition and improve productivity of the production system. Electricity producing Firms therefore need to adopt maintenance management practices (s) which meet these objectives.

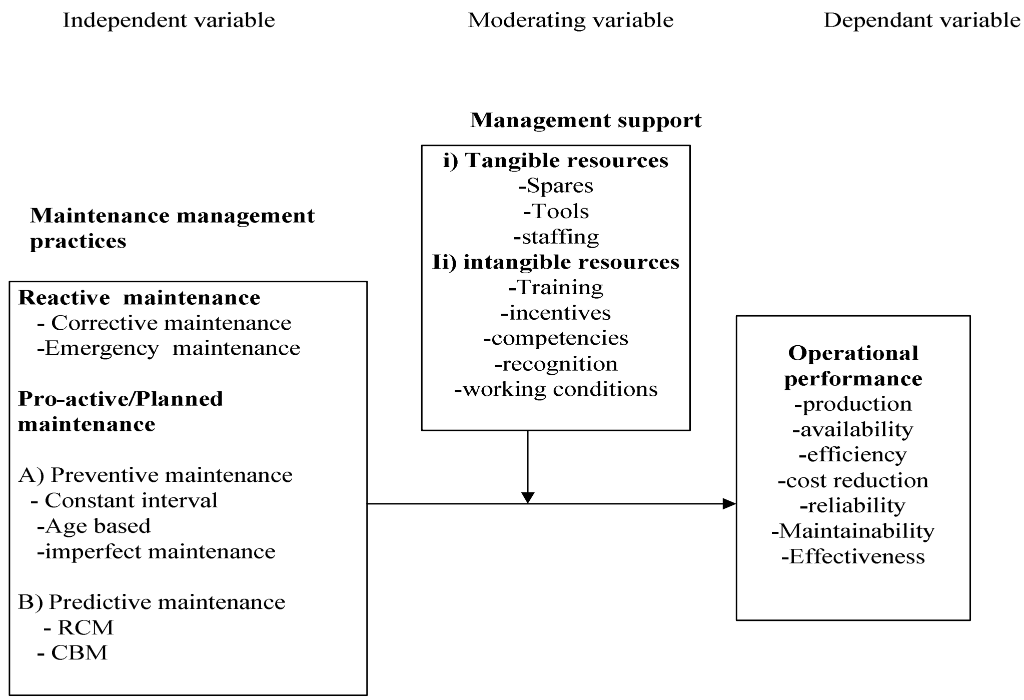
Smith (2003) notes that preventive maintenance offers 12 to 18% maintenance costs reduction over reactive maintenance. Smith (2003) further noted that, predictive maintenance offers 8 to 12 % maintenance costs reduction over preventive maintenance. According to Khan and Darrab (2010), a good maintenance management practice is the one which offers competitive advantages in terms of improving reliability, maintainability and maximizing overall equipment effectiveness (OEE). They asserted that high OEE is evidenced by zero breakdowns, zero accident and in high quality and high productivity.

In RBV theory, Barney (1991) noted that a firm must have unique and intangible VRIN resources to have competitive advantage. However, Danny (2003) observed that competitive advantage does not depend so much on resources but on such intangible assets as skills, processes or assets which a firm cannot cost. These are the intangible assets that Gomes et al., (2011) noted that they were being ignored and were less used as measures of maintenance performance.

The above foregoing clearly leads to a jungle of confusion and conflict which need to be addressed in research: Which are the main maintenance management practices adopted by electricity generating stations and is there a particular maintenance management practice which can be regarded as the best compared to the than others? To what extent do maintenance management practices and management support in terms of tangible and intangible resources impact on operational performance? What challenges do the stations producing electricity in Kenya faced in maintenance management?

2.9 Conceptual Framework

Figure 2.5: Maintenance Management Conceptual Framework



Adapted from; Veldman et al., (2006) and Al-Turki (2011)

Production is defined as the application of process and technology to raw materials to add the use and economic values to arrive at a desired product by the best method. According to Panneerselvam (2009), availability is the proportion of time the equipment is actually available out of the time it should be available. On the other hand, efficiency is producing with minimum waste, expense or unnecessary effort. It is the provision of the same or better maintenance for the same cost (Marquez et al., 2009).

Reliability is the ability of an asset to continue performing its function as required. Maintainability is defined as the ability of an asset to run in a trouble free manner and be easily rectified when it fails. Maintainability is quantified by MTTR (Oakland & Lockkyer, 1992). Effectiveness is the degree of accomplishment of the objectives (Murthy, 2005). The formulae for calculating these operational parameters are in Appendix 1.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with the research design adopted and population of study. The chapter also has data collection and data analysis sections. It is this chapter which guided the achievement of the objectives.

3.2 Research Design

The research design used was descriptive cross sectional survey design. This research design type was chosen because it involved interviews with a large number of respondents using a pre-designed questionnaire in the Appendix 3. Census survey was adopted to enable the data collected to be representative. Survey design was chosen instead of case study or experiment designs since several elements were studied as opposed to case study which involves one entity. Experimental design could not be applicable since the research was not been done in the field and no manipulation of any variable was being done so as to gauge how it affected maintenance management practices in the chosen Firms. Survey eliminates biasness and offers better accuracy of the results (Kothari, 2004).

3.3 Population and Sampling

The units of the study were stations which produce electricity in Kenya. The population of these units was 25 Stations for KenGen (KenGen Diary, 2014) and 4 IPPs (ERC 2012) totaling to a population of 29. Since census survey was applied, all the 29 Stations were targeted in the study.

3.4 Data Collection

The study collected data by means of a Questionnaire (Appendix 3). The Questionnaire was in five-(5) sections. The Questionnaire had been designed and constructed in a way that each section was to gather data in relation to a specific objective of the study. The target respondents were three levels of the stations' management that is; 1 respondent in each level. The target respondents were; Technician, maintenance Engineer and Chief Engineer in each of the stations. There were 3 persons targeted per station. Therefore, considering there were 29 Stations to be studied, the targeted respondents were 87.

3.5 Data Analysis

The data obtained was analyzed through measures of central tendency. These are frequencies, means and standard deviations. Graphs showing regression relationships have also been used. From these equations, the percentage level of effect of the independent variables on the dependant variables has been highlighted.

To analyze the impact of the adopted maintenance management practices on the organizational performance, multiple regression analysis was used to determine if there was any correction between maintenance management practices and organization performance. The regression model adopted was:

$$y=a+bx_1 + c x_2 + \varepsilon$$

Where,

y= Organizational performance as the dependent variable

x_1= Management practices as the independent variable

x_2= Level of top management support as the moderating variable

a= y intercept when x_1 **and** x_2=0

b, c = Coefficients of y

ε= Error term

Further, section 4 articles (2.) and (3.) were testing maintenance management practices adopted as input/output model. The means of the inputs side and that of the outputs side were compared so as to get the efficiency (as a measure of operational performance) of the maintenance management practices adopted using the model:

$$E= I/ O$$

Where,

E= Efficiency

I= Inputs

O=outputs.

CHAPTER FOUR: DATA ANALYSIS, FINDINGS AND DISCUSSION

4.1 Introduction

This chapter is composed of the analysis of the data which was collected by mean of a Questionnaire. The Questionnaire targeted to receive data from a population of twenty nine-(29) electricity producing stations in Kenya. Responses were received from seventeen-(17) stations. This represented a 58.62 % response rate. According to Mugenda & Mugenda (1999), a response rate of above 50% is adequate for analysis and reporting. The installed capacity of the stations which responded was 1,121 Mw representing 63. 77% of the total population installed capacity of 1,758.18 Mw.

The above response rate was not obtained easily. It was achieved through constant e-mails, mobile phone short text messages and phone calls reminders. Based on the analyzed data, some findings have been made. Discussion of the analyzed results has been done in relation to each specific objective's findings and the literature review so as to answer the identified gaps and also to confirm or disagree with past researchers findings. Further, the analysis has provided some body of knowledge.

4.2 Preliminary Information

This section was concerned with getting the demographics of the respondents as well as that of the population of study. Generally, it also gathered information subsequent to the other four sections. This information gathered in advance of the information in the subsequent sections has been correlated to ascertain as to whether the stated data were consistent with the calculated values.

4.2.1 Respondents Profile

The Questionnaire sought to obtain information from four-(4) personnel from each station namely Chief Engineer, Engineer, Superintendant and Technician. Only one response per station was required. The aim of sending to four personnel was to improve the response rate where all the above designations existed. Further, it sought to obtain information from all the stations since it was found that some stations were been headed by Superintendants and therefore did not have a chief Engineer or an Engineer.

From the responses obtained 27 of the respondents were male and 2 were female representing 93% male gender response and 7% female gender response. It was found out that most of the Chief Engineers, Engineers, Superintendants and Technicians involved in the Stations' maintenance management were predominantly male. This research shown that the female gender were shying away from maintenance management jobs or simply they avoided such courses right from college in preference for other professions.

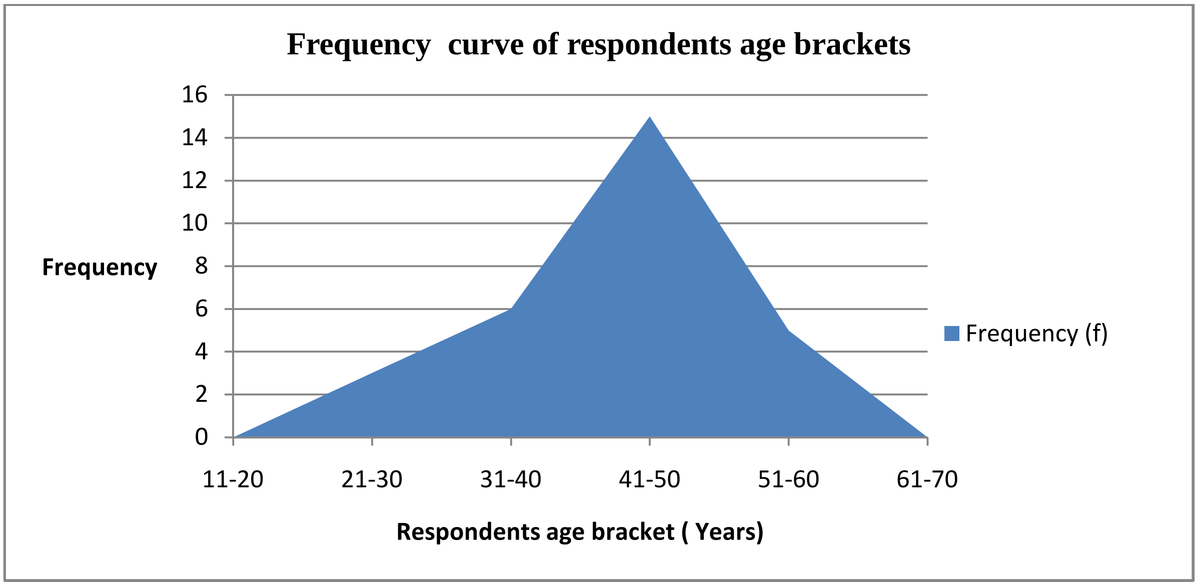
The 29 responses obtained were as follows, 7 Chief Engineers, 8 Engineers, 9 Superintendants and 5 Technicians. An analysis of the age brackets in years was as per the table below.

Table 4.1: Age Profile of the Respondents

Age bracket (Years)	**Class lower Age (Years)**	**Frequency (f)**	**Less than cumulative frequency**	**Class mid-point (x)**	**fx**	**$x - \bar{x}$**	**$(x - \bar{x})^2$**
21-30	21	3	3	25.5	76.5	-17.586207	309.275
31-40	31	6	9	35.5	213	-7.5862069	57.5505
41-50	41	15	24	45.5	682.5	2.4137931	5.8264
51-60	51	5	29	55.5	277.5	12.4137931	154.102
				Total	**1,249.50**		**526.75**

Most of the respondents were in age bracket of 41- 50 years. There were 15 respondents from this age bracket. The mean age of the respondents **($\bar{x}$)** was 43 years at a standard deviation of 8.57. The standard deviation is small indicating the mean is very close to the true value. The frequency curve below graphically represents these findings.

Figure 4.1: Frequency Curve Indicating Age Profiles of the Respondents



As regards the numbers of years the respondents had worked in his/her current station, the table below summarizes the findings. Most of the respondents had worked for less than 2 years in their current stations followed by those who had worked for 10 to 15 years. The table shows that the response rate did not follow any particular pattern. However respondents who had worked for less than 2 years and those who had worked for 10-15 years seemed to have high interest in maintenances management practices of their stations.

Table 4.2: Summary of Years the Respondents Had Worked In their Station

Number of years the Respondents had worked in the Station	Frequency (f)	Less than Cumulative frequency
>2	11	11
2-5	2	13
5-10	6	19
10-15	8	27
< 15	2	29
Total	**29**	

4.2.2 Population Profile

Responses were obtained from 17 stations. The respondents' stations mix of mode of generation of electricity was as per the table below.

Table 4.3: Electricity Generation Mix of Respondents' Stations

Item No.	Mode of Electricity Generation	Response	Target	Response Rate
1	Diesel	3	7	43%
2	Gas Turbine	1	1	100%
3	Geothermal	4	5	80%
4	Hydro	8	15	53%
5	Wind	1	1	100%

The above table shows that responses were obtained from all the targeted 5 electricity generation modes. The highest response rate was gotten from stations generating electricity from geothermal resource. Therefore, the findings of this research adequately represent maintenance management practices in the electricity generating stations regardless of the mode of generation.

As regards the number of years the power stations have been working, the following table summarizes the findings.

Table 4.4: Number of Years the Respondents' Stations have been Running

Numbers of years the station have been running	Frequency (Number of stations)	Cumulative Frequency
<2	2	2
2-5	3	5
5-10	5	10
10-15	1	11
>15	18	29

Most of the responses were obtained from stations which had been running for more than 15 years. Therefore, the findings of this study establishes as to whether age of station affects its operational performance or not. The study also helps to determine if cost of maintenance goes up as the assets ages or not.

As relates to the cost of maintenance in relation to the total station's costs, the Tables 4.6 and 4.7 below summarize the findings. Table 4.6 shows the calculated maintenance cost levels for the various mix of electricity generation. Table 4.7 shows the calculated overall maintenance cost in electricity producing stations.

Table 4.5: Levels of Maintenance Costs in the Different Mix of Electricity Generation Mode

Class of % Maintenance Cost over total station cost	**Frequency**				
	Hydro Stations	**Geothermal Stations**	**Diesel Stations**	**Gas Turbines**	**Wind Turbines**
10-20	7	1	1	0	1
20-30	2	1	1	1	0
30-40	1	1	3	0	0
40-50	2	2	1	0	0
50-60	0	0	0	0	0
Total	**12**	**5**	**6**	**1**	**1**
Mean	**23.33%**	**33%**	**31.66%**	**25%**	**15%**
Standard deviation	**11.42**	**11.66**	**9.42**	**0**	**0**

From the above table, 4 respondents did not indicate the maintenance costs levels in their stations. This may be because they were not aware of it. It is important that, personnel charged with maintenance management practices in the stations are aware of the maintenance costs levels in their stations. This would offer the baseline from which to reduce the maintenance cost level. From the above findings, Hydro power stations and geothermal power stations maintenance costs are about 23.33% and 31.66% respectively. The 31.66% maintenance cost of Diesel stations may not be very accurate since the response rate from Diesel stations was below 50% (at 43% from Table 4.3), which is not good for research (Mugenda & Mugenda, 1999).

Table 4.6: Levels of Maintenance Costs in Electricity Generating Stations

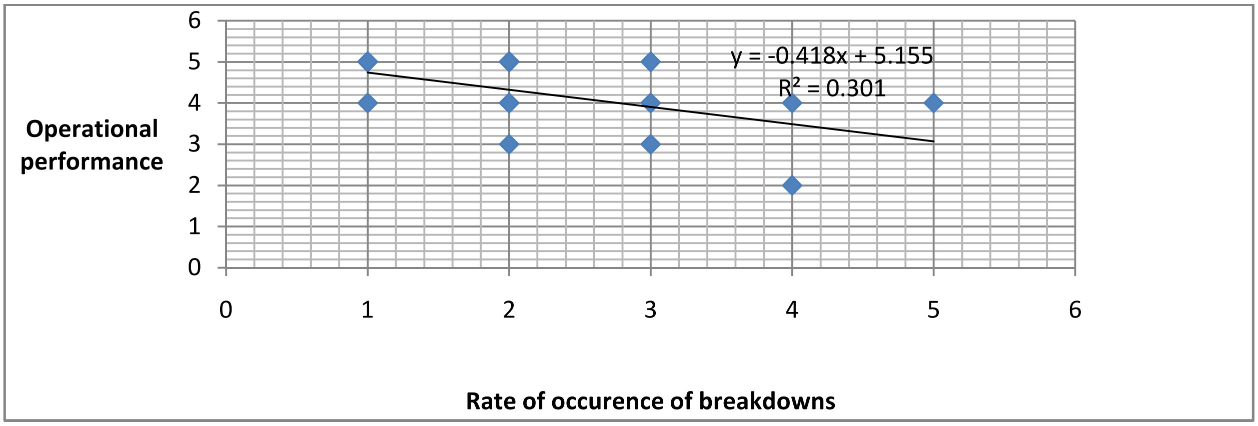
% Maintenance cost class	Frequency (f)	Cumulative frequency (c f)	lower limit	Class mid-point (x)	fx	$x - \bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
10-20	10	7	10	15.0	150	-12.0	144	1440
20-30	6	13	20	25.0	150	-2.0	4	24
30-40	3	16	30	35.0	105	8.0	64	192
40-50	6	22	40	45.0	270	18.0	324	1944
50-60	0	22	50	55.0	0	28.0	784	0
Total	**25**				**675**			**3600**

The mean maintenance cost in relation to the overall organization running cost obtained from the above table was 27% at a standard deviation of 12. As Al-Turki (2011) had noted, maintenance costs are normally high at about 30% of the total organization running costs. Cross had noted that this value is normally 25%. Their findings closely agree with this research findings of 23.33 to 33% and with single point value of 27% obtained from Table 4.7.

Therefore, for operational performance to be optimized, maintenance costs need to be minimized. This objective of minimizing maintenance costs can be achieved if the best maintenance management practices are adopted (Al-Turki, 2011). Moreover, breakdown maintenance management practices should be avoided since they are expensive compared to other maintenance management practices as Murthy (2005) noted.

The analyzed data obtained from the rest of Section 1 on preliminary information, was as follows.

Figure: 4.2: Relationship between operational performance and rate of occurrence of breakdowns



The above figure shows that operational performance of the stations has a negative relationship with the maintenance cost, since the coefficient of x in the regression equation is negative. This is explained by the fact that during breakdowns, the machine is not available for electricity production hence availability and productivity as measures of operational performance goes down (Dilworth, 1992). Also, since breakdown maintenance are very expensive compared to other maintenance management practices (Murthy, 2005), the maintenance costs goes up thus increasing production cost per unit. Therefore, breakdowns have a negative impact on operational performance. Since R^2 value is 0.301, it shows that, breakdowns occurrence and their duration negatively affect operational performance by 30%, which is quite significant.

Figure 4.3: Relationship between Operational Performance and Cost of Maintenance

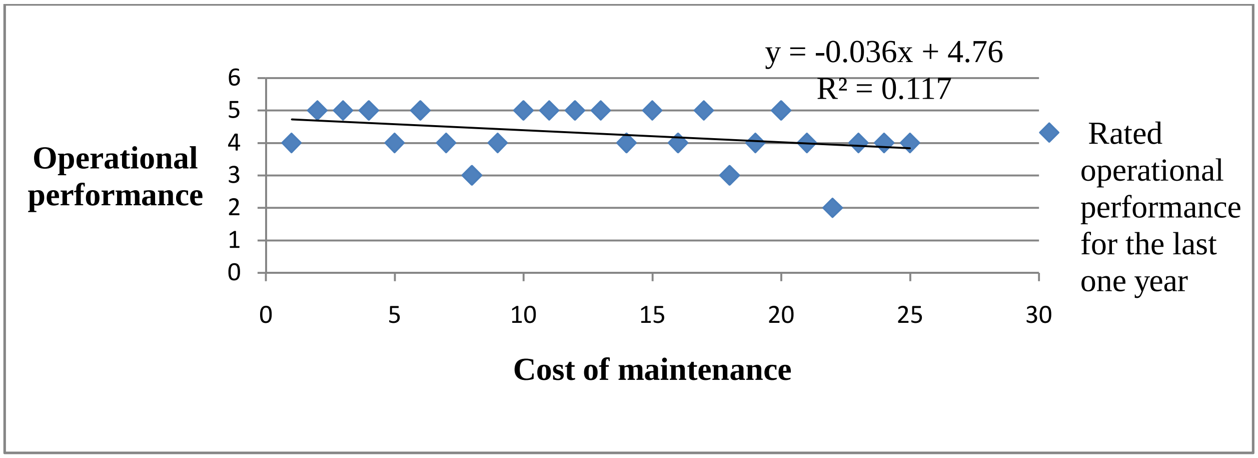
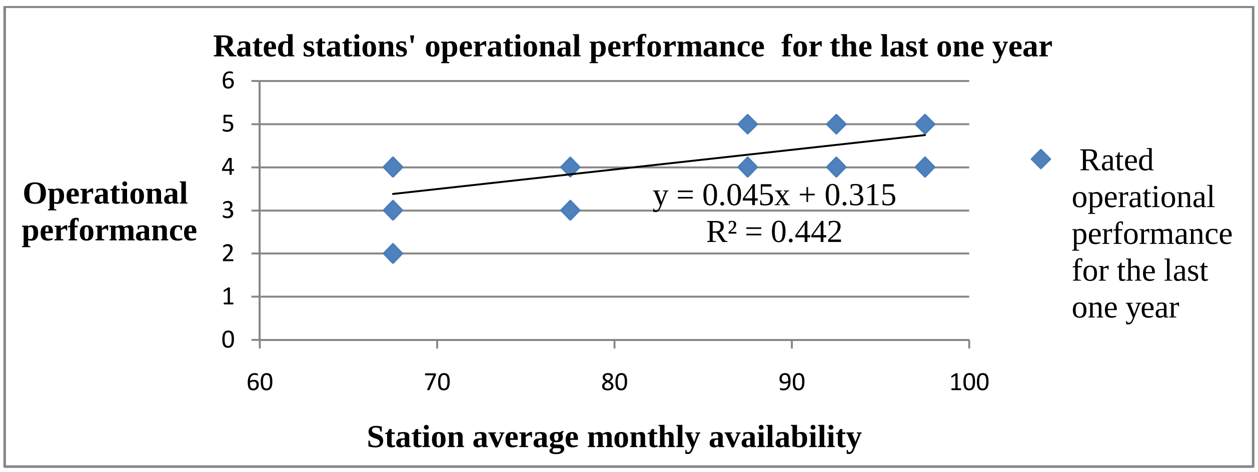


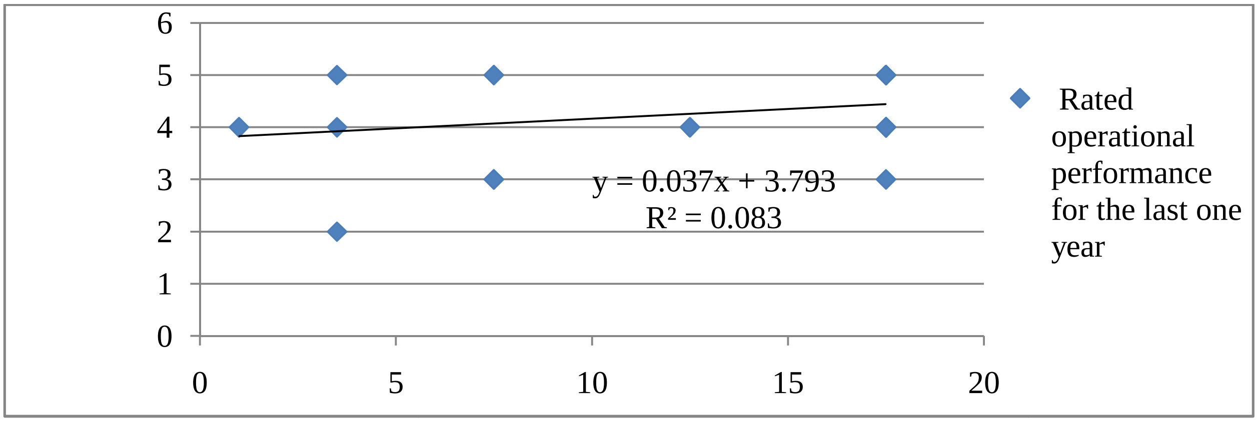
Figure 4.2 above shows that the cost of maintenance negatively affects operational performance by 11.7%, less than the occurrence of a breakdown, which negatively affects operational performance by 30.1 % (Figure 4.1). This can be explained by the fact that the cost of breakdown repair may be high, but if the breakdown is attended to on time, availability and productivity can still be high. Further, analysis of maintenance system as an input/output model reviewed that, cost of maintenance does not affect efficiency of production. The analysis reviewed that, there is a very weak relationship between the two. Efficiency being a ratio of outputs to inputs (Murthy, 2005), there are some inputs which may be intangible and therefore may be difficult to cost them e.g. training, skills and competencies (Danny, 2003).

Figure 4.4: Relationship between Operational Performance and Average Monthly Availability of the Stations



The above figure shows that availability is a strong indicator of operational performance. R^2 being 0.442, its shows that 44.2% of operational performance is determined by the time the machine is available for production. This is true because, if the machine is not running, other measures of operational performance such as reliability, production cost per unit, maintainability, mean time to failure and productivity will either be affected or cannot be determined.

Figure 4.5: Relationship between Operational Performance and Number of Years the Plant had operated



The table 4.4 above shows that, the years a power station has been running does not significantly affect operational performance. It does so to an extent of 8.3%. Therefore, the results obtained in pursuit of the specific objectives are not affected by the ages of the stations.

4.3 Extent of Application of the Various Maintenance Management Practices

This was the first specific objective of the study. The figures below show the extent of application of the various maintenance management practices.

Figure 4.6: Extent of Application of the Various Maintenance Management Practices

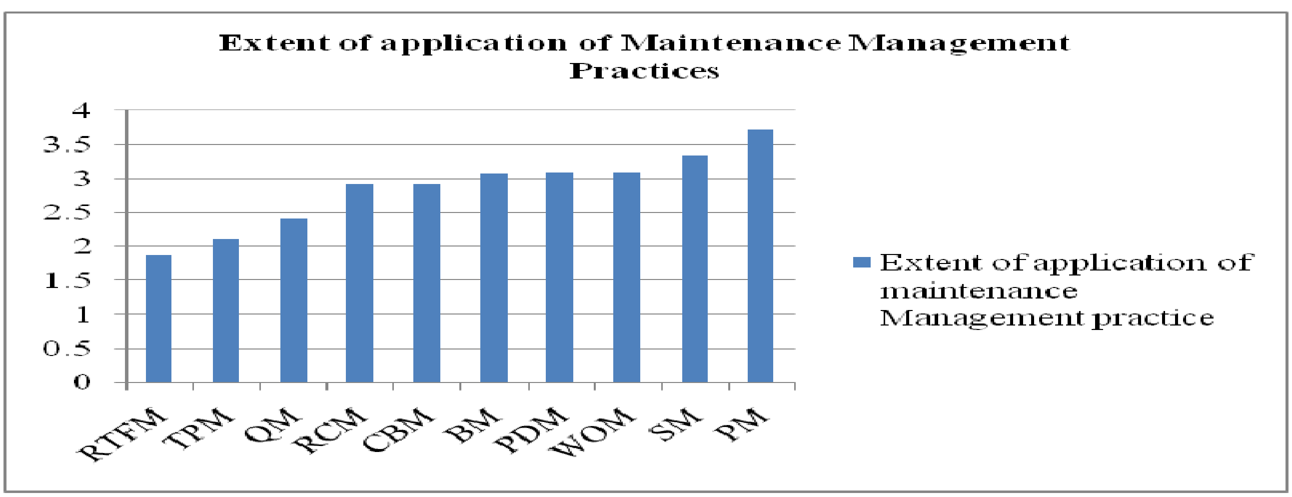
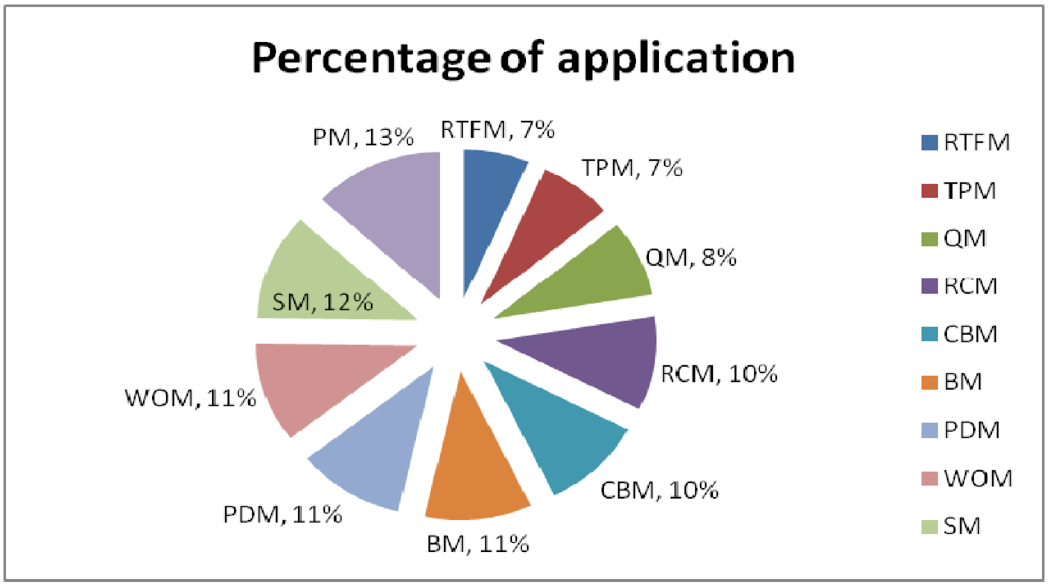


Figure 4.5 shows that the most used maintenance management practice is preventive maintenance (PM). This is followed by scheduled maintenance (SM), work orders maintenance and predictive maintenance. The least used maintenance management practice is ‘run to failure maintenance (RTFM) followed by total productive maintenance and quality maintenance. The findings of the percentage application of the various maintenance management practices were as per figure 4.6 below.

Figure 4.7: Extent of Application of the Various Maintenance Management Practices



Total productive, reliability centered, condition based, predictive, work order and scheduled maintenance management practices can all broadly be classified as preventive maintenance management practices (Murthy, 2005). The percentage application of these maintenance management practices were merged together. Figure 4.8 below displays the findings.

Figure 4.8: Extent of Application of Maintenance Management Practices broadly classified and Expressed in Percentage

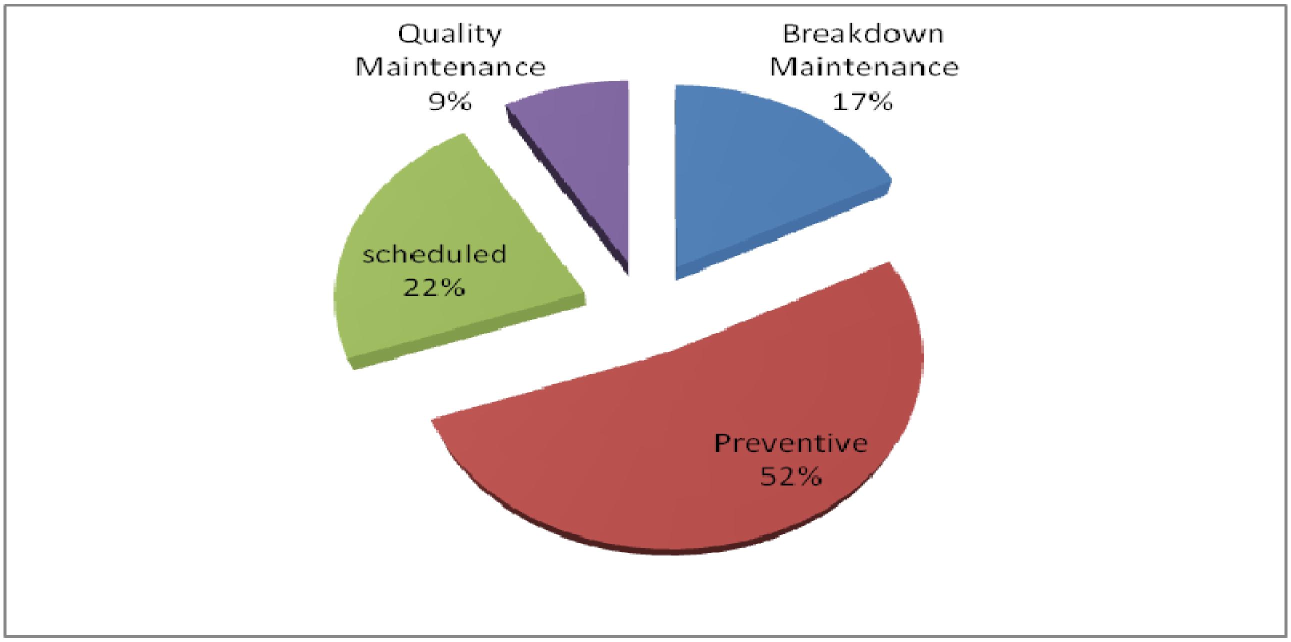


Figure 4.8 above shows that preventive maintenance management practice is the most applied in electricity producing stations at 52% followed by scheduled maintenance management practice at 22%. Though breakdown maintenance should be avoided since it is expensive and disrupt productions (Smith, 2003), it still accounted for 17%. This meant that, most of the times the electricity producing stations were either caught unaware by breakdowns or deliberately run the machines to failure. This is because the study found out that there was 7 % application of run to failure maintenance.

4.4 Level of Top Management Support for Maintenance Management

Establishing the level of top management support for maintenance management was the second specific objective. The study found out that there was low support for maintenance management practices in the electricity stations in most of the support required areas. Further, it was found out that, top management support in these stations for benching marking opportunities with best practices and provision of performance based rewards/incentives was very low.

The findings revealed that the area which the top management supported the most was in budgetary allocation for maintenance management practices. Top management also provided adequate human resource for maintenance works and also motivated the workers to an average extent. The level of top management support in the various areas, as found out by the study, was as per the table 4.7 below.

Table 4.7: Ranking of Top Management Support for Maintenance Management

Rank No.	**Top Management support required**	**Percentage level of Top Management support**
1.	Adequate budgetary allocation	64%
2.	Level of maintenance staffing	62%
3.	Provision of motivation	62%
4.	Provision of modern tools and equipment	59%
5.	Provision of technical training	59%
6.	Provision of allowances	58%
7.	Provision of experts diagnostic /trouble shooting Systems	54%
8.	Recognition of work performance	51%
9.	Provision of opportunities for bench marking with best practices	44%
10.	Presence of performance based rewards/incentives	39%

The study also found out that between tangible assets and intangible resources, none can be said to offer higher operational performance than the other. However, both are required to enhance operational performance. These research findings revealed that, as top management procured new technologies, they equally trained employees to be able to use the new equipment and technologies. Therefore, in the Resource based view theory, both tangible and intangibles assets are needed almost in equal measure for a firm to have competitive advantage.

4.5 Determining The Impact Of The Adopted Maintenance Management Practices On The Organization's Operational Performance With Management Support As The Moderating Variable.

This was the third specific objective of the study. The Table 4.8 below shows the data collected from the 17 stations which responded as regards extent of application of maintenance management practices, level of top management support and operational performance. Each of this was out of a Likert scale of out of 5. Since breakdown and run to failure maintenance practices are negative maintenance management practices since they are done when the asset has actually broken down (Pannerrselvam, 2009), their means were assigned negative values.

Table 4.8: Data on Extent of Application of Maintenance Management Practices, Level of Top Management Support and Operational Performance

Item No.	Power Station	Management Support	Extent of application of Maintenance Management Practices	Operational performance
1.	PS'1	2.80	2.2	4.0
2.	PS'2	2.10	1.0	3.7
3.	PS'6	2.90	2.1	3.9
4.	PS'7	2.70	2.3	4.8
5.	PS'8	3.30	2.4	3.8
6.	PS'9	2.90	2.0	3.2
7.	PS'10	3.90	2.7	4.3
8.	PS'12	2.70	2.2	4.4
9.	PS'15	2.20	1.3	4.1
10.	PS'16	2.60	1.9	4.6
11.	PS'17	2.40	1.9	3.5
12.	PS'18	2.20	1.9	3.6
13.	PS'23	3.10	2.4	4.2
14.	PS'25	2.50	1.7	3.6
15.	PS'27	2.10	1.1	3.8
16.	PS'28	2.00	1.7	3.9
17.	PS'29	3.70	2.1	3.6

The following model was adopted.

$$\mathbf{y=a+ bx_1 + c\, x_2 + \varepsilon}$$

Where,

y= Organizational performance as the dependent variable

$\mathbf{x_1}$= Management practices as the independent variable

$\mathbf{x_2}$= Level of top management support as the second independent variable

a= y intercept when $\mathbf{x_1}$ **and** $\mathbf{x_2}$=0

b, c= Coefficients of x_1 and x_2

ε = Error term

The above data in Table 4.8 was analyzed using SPSS (Statistical Package for Social Sciences) Version 20. The following Tables show the outputs which were obtained.

Table 4.9 Model Summary[b]. The Co-efficient of Determination or Correlation Between The Dependent and Independent Variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.382[a]	.146	.024	.41344	2.004

a. Predictors: (Constant), Extent of application of maintenance management practices, Level of management support

b. Dependent Variable: Operational Performance

The Table 4.9 above shows that the coefficient of determination indicate that management support and maintenance management practices account for 2.4% (adjusted r squared = 0.024) of the factors that affect operational performance.

Table 4.10: Analysis of Variance (ANOVA)

Model		Sum of Squares	Degree of freedom	Mean Square	F	Sig.
1	Regression	.408	2	.204	1.194	.332[b]
	Residual	2.393	14	.171		
	Total	2.801	16			

a. Dependent Variable: Operational Performance

b. Predictors: (Constant), Extent of application of maintenance management practices, Level of management support

The Table 4.10 above explains whether the model is significant or the strength of the impact between the dependent and independent variables. The model was tested at a significant level of 0.95 where the p value is 0.05. The table shows a p value of 0.332. This therefore denoted an insignificant relationship. The model is poor to represent the relationship.

Table 4.11: The Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Significance
		B	Std. Error	Beta		
1	(Constant)	3.613	.553		6.530	.000
	Level of management support	-.206	.266	-.262	-.777	.450
	Extent of application of maintenance management practices	.465	.309	.508	1.508	.154

The Table 4.11 above shows the specific influence of each of the independent variables against t operational performance which is the dependent variable.

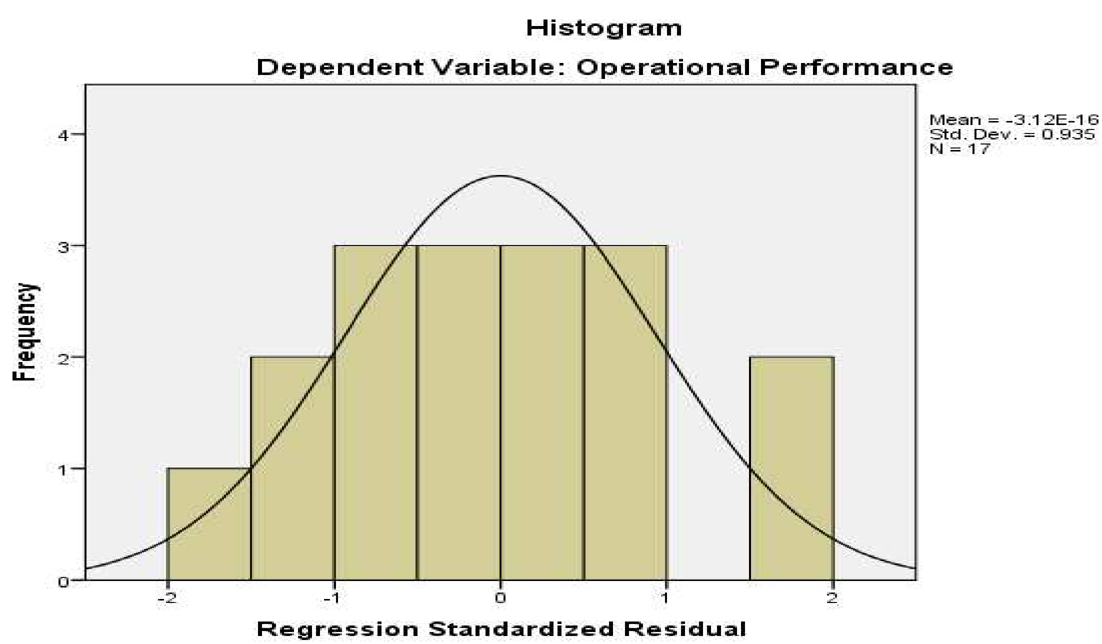
From the study model, $y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$, the model interpreted took the following form;

$y = 3.613 - 0.206x_1 + 0.465x_2 + 0.41344$

Without considering top management support and maintenance management practices, operational performance of the stations was constant at 3.613. However level of top management support led to 0.206 decline in operational performance while maintenance management practices increased operational performance of the stations by 0.465. The error term was quite big in relation to impact of the independent variables. Since maintenance management practices had a positive coefficient, it meant it had a positive relationship with operational performance. Level of top management support seemed to have a negative relationship. This can be explained by the fact that from the data obtained, the mean of top management support was 2.71 out of a maximum of 5 which indicated on average a low level of top management support which was affecting operational performance negatively.

To give further insight, residual plots which indicate the differences between the response values in the raw data collected and the expected values from the model were plotted. The plot showed that the residuals were following normal distribution. Therefore, the model was not significant to represent the relationship.

Figure 4.9: Plot of Residuals of first Regression Model



Since level of top management support had a negative relationship with operational performance, it was eliminated and a new model was developed. The outputs were as follows:

Table 4.12 Model Summary[b] (Testing Without Management Support)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.330[a]	.109	.049	.40793	1.936

a. Predictors: (Constant), Extent of application of maintenance management practices

b. Dependent Variable: Operational Performance

Table 4.13: ANOVA

Model		Sum of Squares	Degree of freedom	Mean Square	F	Sig.
1	Regression	.305	1	.305	1.833	.196[b]
	Residual	2.496	15	.166		
	Total	2.801	16			

a. Dependent Variable: Operational Performance

b. Predictors: (Constant), Extent of application of maintenance management practices

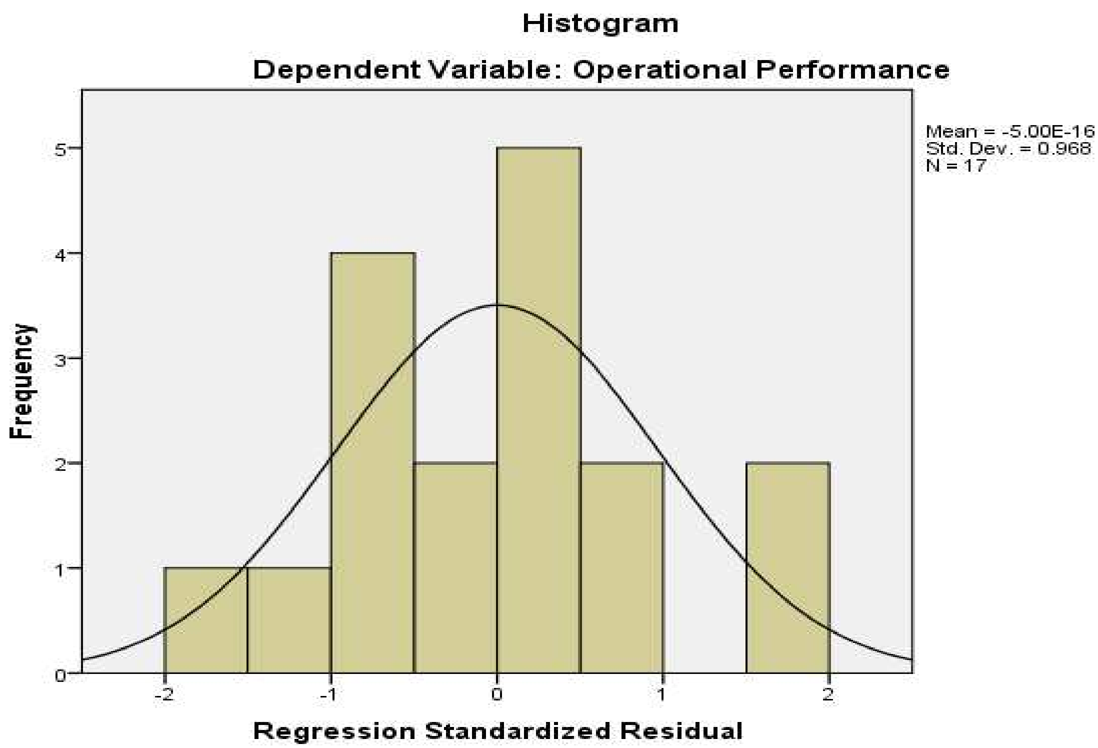
Table 4.14: The Regression Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Significant
		B	Std. Error	Beta		
1	(Constant)	3.359	.441		7.618	.000
	Extent of application of maintenance management practices	.302	.223	.330	1.354	.196

a. Dependent Variable: Operational Performance

The new model was therefore: $y = 3.359 + 0.302x_2 + 0.40793$. The Coefficient of determination (r squared) was now 0.049. This indicated that the extent of application of maintenance management practices contributed to 4.9 % impact on operational performance. The residual plot of this model in figure 4.10 shown that the residuals did not follow a normal distribution showing this was a better representation of the model however the model was also not significant since the p value was 0.196 which was still above the significant level of 0.05 but lower than the first model which had a p value of 0.332.

Figure 4.10: Residual plot of the second Regression model



A further model was developed using Microsoft excel and assuming that there was no error. The following was the output.

Figure 4.11: Regression Model Using Microsoft Excel Assuming Error Term of Zero

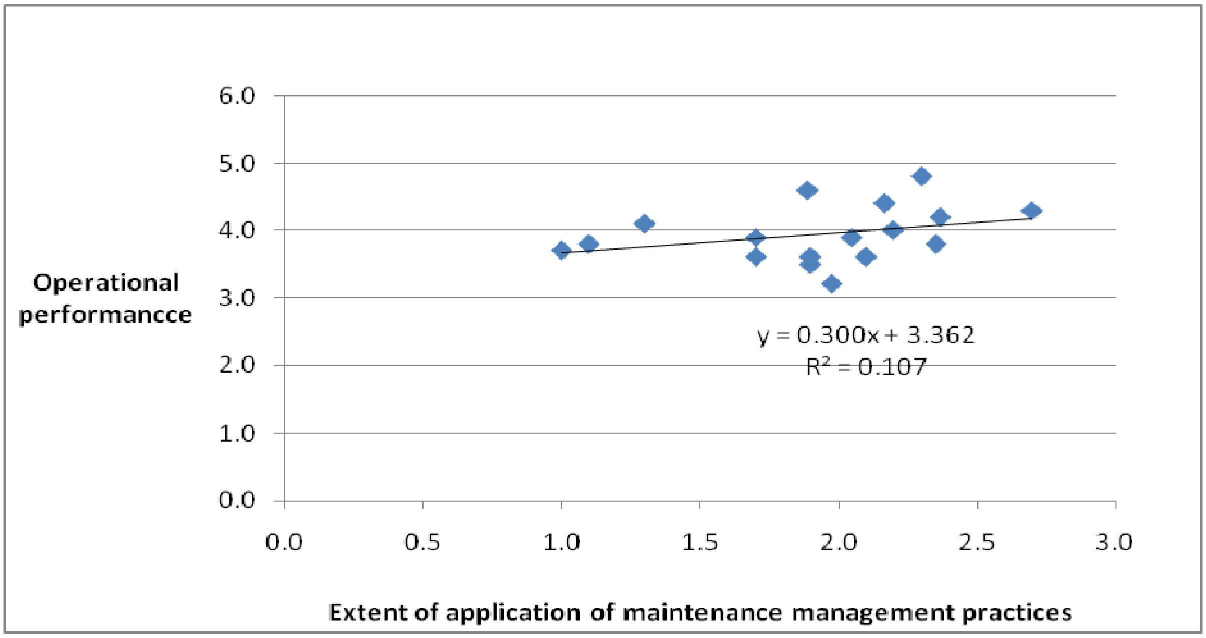
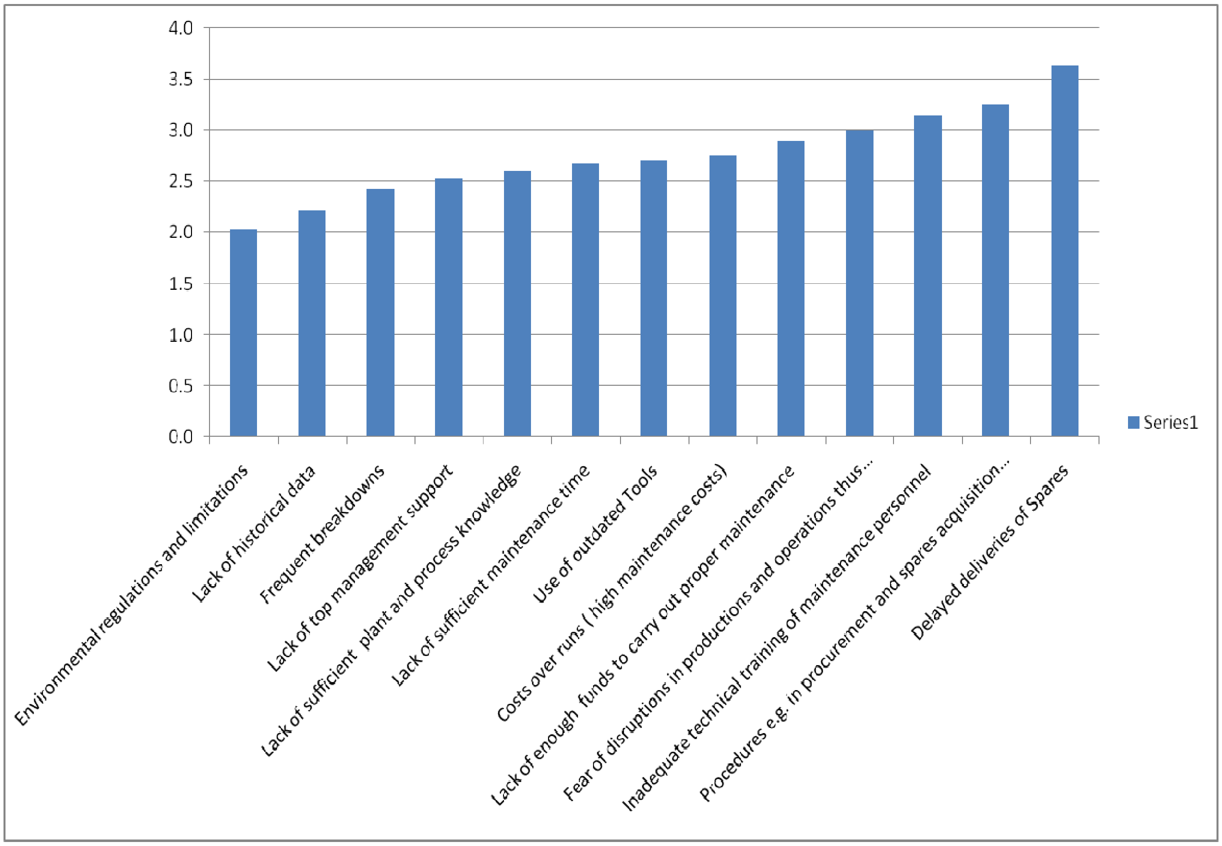


Figure 4.10 also shows that extent of application of maintenance management practices has a positive relationship with operational performance. An increase in level of application of maintenance management practices led to increase in operational performance. In the absence of error, since R^2 was 0.107, it showed that extent of application of maintenance management practices had a 10.7% impact of operational performance.

4.6 Challenges Faced in Maintenance Management

Establishing the challenges faced in maintenance management was the fourth specific objective. The research reviewed that, the highest challenge encountered in maintenance management was delay in spares delivery. This was followed by procurement procedures and acquisition of spares from the stores. Inadequate training of the maintenance personnel was also a significant challenge. The least challenges encountered were environmental regulations and limitations, lack of historical data and frequent breakdowns. Since the stations practiced preventive maintenance at a great extent of 52% (figure 4.7), this made breakdown occurrences to be minimal since preventive maintenance prevent breakdowns (Wild, 2002). The ranking of the challenges encountered by the stations, from the lowest to highest challenge as found out by the study was as per figure 4.8 below.

Figure 4.12: Ranking of challenges encountered in maintenance management by stations producing electricity in Kenya



4.7 Discussion of Results

The findings of the study in relation to each of the specific objective were compared with the literature review. It was found out the findings agreed with the works of past researchers. The findings of the study are discussed below in relation to each objective.

As relates extent of application of maintenance management practices and operational performance, the study found out that the two had a positive relationship. The model equation developed shown that, as the extent of application of maintenance management practices increased, the operational performance also increased. However, the influence of extent of application of management practices on operational performance, eliminating all causes of error was found out to be 10.7%. This meant that, operational performance also depended on other many factors.

According to Gupta and Marquez (2005), the other factors which affect operational performance are productivity and costs. This study findings agrees with this observation and found out that costs of maintenance negatively affected operational performance (Figure 4.2) in the absence of error, the figure indicates that costs of maintenance had a 11.27% influence on operational performance. The other factors which affect operational performance are maintenance controls (Al-sultan & Duffuaa ,1995) and maintenance policy, reliability measures such as mean time to failure and mean time to repair (Sharma & Yadava, 2011).

The study findings on extent of application of management practices also agree with the recommendation by Daya and Duffaa (1995). The two had noted that maintenance practices should be viewed as a value adding activity instead of a necessary evil of expenses. The findings of the study truly show that an increase in extent of application of maintenance management practices added value as it resulted to an increase in operational performance.

According to Wilson (2002) some business processes which should be used for optimizing operational performance are: minimizing maintenance costs, adopting optimal maintenance practices, maximizing plant utilization and capability and maximizing performance efficiency. These observations totally agree with the findings of this study. This is because the study found out that cost had a negative relationship with operational performance (figure 4.2). The study also found out that optimal maintenance practices increased operational performance. This study also found out that some power stations were not operating at full capacity that is, the production machines utilization rate was below 100%. Dividing outputs by inputs to get maintenance performance efficiency (Murthy, 2005), the study found out that one station had a maintenance performance efficiency of below 100%. Coincidentally, this same station recorded the lowest operational performance out of the 17 stations which responded. Therefore, the observations by Wilson (2002) totally agree with the findings of this study.

Further, Ben- Daya et al., (2000) had also identified equipment availability as a measure of a Firm's operational success. This agrees with the finding of this study since it was found out that availability had a very strong positive relationship with operational performance (Figure 4.3).

On maintenance management practices, the study found out that, as breakdown and run to failure maintenance level went down, operational performance was being enhanced. This agrees with Eti et al., (2005) who noted that reduction of failure rate can be a measure of optimized maintenance. Further, Marseguerra et al., (2002) had noted that preventive maintenance greatly positively influenced operational performance. This is exactly what the study found out and is evidenced by a 52% application of preventive maintenance (Figure 4.7) which surpasses the minimum level of preventive level of 30% recommended by Smith (2003).

In the analysis of data, the means of the collected data on breakdown and run to failure maintenance were assigned negative values. The regression models shown that, operational performance was increasing with an increase in level of application of maintenance management practices. Therefore, this meant that, if breakdown and run to failure maintenance can be avoided, operational performance can be optimized. This agrees with the Murthy (2005) and Wilson (2002) that breakdowns negatively affect productivity hence operational performance.

As already noted by several researchers, maintenance costs are normally very high at around 25 - 30% (Komomen 2002) of total organization running cost. This closely agrees with the findings of this study at 23.3 to 33% and average of 27% (Table 4.7). Further, according to Hannequin and Arango (2009) some maintenance management practices such as total productive maintenance and total quality maintenance require great investments in human and information resource. This explains why the study found out that the extent of application of these maintenance management practices was low.

On management support, Armstrong (2000) had noted that competitive advantage is attained by developing core competencies in the workforce. Such development of competencies should include training of workforce, rewards systems and provision of the required resources to perform the work so as to enhance operational success of a Firm. It is also notable that top management support for maintenance management practices in organizations is seldom since maintenance is wrongly regarded as being a non-strategic function (Al-Turki, 2011). The study found out a similar observation that level of top management support was low. Further, it was the finding of this study that inadequate training of maintenance personnel was a major challenge. According to Gupta et al., (2011), organizations in pursuit of their operational success overlooked the human factor in operational performance. Further, Hipkin and Cock (2000) had asserted that management support is the tipping board between operational success and failure. This best explains why the low top management support observed in this study resulted in a decline in operational performance.

On the challenges encountered Visser (1998) had argues that, a body of knowledge was lacking to clearly guide maintenance management. This led to difficulty in decisions making as to which maintenance delivery strategy to adopt (Marquez & Gupta, 2005). The study findings agreed with that. From figure 4.6, the findings were that there was no one particular maintenance management practice which was largely being used than the other. All had 7- 13% level of application. From the figure, Run to failure maintenance and total productive maintenance tied at 7% level of application, RCM and CBM at 10% and WOM, BM and PDM tied at 11% level of application. This therefore agrees with the argument of Ahmed and Duffaa (1995) that, there is no universally accepted maintenance management practice. However, some maintenance practices have been known to result to higher overall cost reductions than others (Marquez & Gupta, 2006). These observations by these past researchers therefore agree with the findings of this study. My study found out that preventive maintenance practices were offering an increase in operational performance. Further, breakdown and run to failure maintenance were leading to decline in operational performance.

While this study agrees with most of the observations by past researchers, it disagreed Hipkin and De Cock (2000), ranking of challenges in the implementing maintenance systems. The challenges indentified by the two were found out by this study to be low challenges in stations producing electricity in Kenya. This can be explained by the fact that challenges can differ from one industry to the other. Further, challenges can depend with management style applied, level of top management support and systems put in place to mitigate the challenges.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter is comprised of a summary of the findings made as a result of the data analyzed. Further, the chapter has made some conclusions based on the study. It also extracts the limitations of the study and how the limitations were overcome. Based on the findings, suggestions for areas of further research have been outlined. Finally, the chapter draws certain recommendations to the management of the stations which were studied.

5.2 Summary of Findings

Maintenance cost level in relation to the overall organization running costs was found to be high at 15 to 33 % and at an average of 27%. The occurrence of breakdowns and the cost of the breakdowns were found to have a negative effect on operational performance. However, availability of the electricity producing machines was noted to have a very high influence on operational performance at 44.2% in the absence of any error. It was found that, as availability increased, the stations' operational performance was increasing. The years the stations had run was also found to have a positive effect on operational performance. This can be explained by the level of experience developed by the maintenance staff in those stations which enabled operational challenges to be dwelt with timely.

As relates extent of application of maintenance management practices, the study found out that they was no one particular practice which was largely applied in relation to the others. All maintenance management practices seemed to be applied almost equally. The highly applied maintenance management practices were however work orders maintenance, scheduled and preventive maintenance. The lowly applied practices were run to failure, total productive and quality maintenance. Broadly, preventive maintenance practices were largely been applied than reactive maintenance.

As regards the level of top management support for maintenance management, the level was found to be low. This was causing a decline effect on operational performance. However, above average top management support was observed in budgetary allocation and staffing level. Low top management support was observed in recognition of work performance, performance based rewards and incentives. Also, top management support for bench marking opportunities with other firms and best practices was also found to be low.

The extent of application of maintenance management practices had a positive impact on operational performance. It was however observed that, inadequate training of maintenance personnel, spares acquisition procedures and delay in delivery of spares were the greatest challenges encountered in the stations producing electricity in Kenya.

5.3 Conclusions of the Study

The study concludes that, maintenance costs are high in stations producing electricity. Further, there seems to be other factors which greatly affect operational performance. However, availability effect on operational performance was high. It is therefore important to enhance availabilities of the Stations so as to maintain higher operational performance. The challenges encountered in these stations and the low level of management support seemed to be some of the other factors affecting operational performance. Top management of the stations under study need to up their support for maintenance management, enhance availabilities of their stations and deal with the challenges in their Stations if they are to improve the operational performance of their Stations.

5.4 Limitations of the Study

Time was a great limitation of this study. This study was supposed to be concluded in a given timeline. This limitation was overcome by devoting a lot of time to this study after my normal working hours. Most of my weekends were spent out in hotel rooms working on this project so as to complete it on time.

There also seemed some resistance by some target respondents to fill out the questionnaire. This was overcome by constant phone, short text messages and e-mail reminders as to record a response rate of over 50%. However, despite these efforts, response rate of over 60% could not be obtained.

This study was confined within a scope of four specific objectives. These limited the amount of information and data gathered. Hence, only the impact of two factors on operational performance (management support and extent of application of maintenance management practices) was studied. This has been overcome by suggesting research to be done on the major factors which affect operational performance.

5.5 Suggestions for Further Research

From this study findings, level of top management support and extent of application of the various maintenance management practices seemed not to be major factors which affect operational performance. A research should be conducted to establish how the challenges indentified in this study affect operational performance. Future research should also focus on how each element of top management affect operational performance.

Breakdown maintenance has been sighted as the most expensive maintenance practice and should be avoided (Murthy 2005). Specifically, this study has shown that, it is the duration of breakdown which affects operational performance more than the cost of attending to the breakdown. The extent to which breakdowns' duration affects operational performance need to be determined empirically. There is a need also of determining the factors which greatly impact on operational performance.

5.6 Recommendations

It is recommended that, top management of the stations studied should devise ways of reducing the high maintenance costs in their stations. They need to explore the best maintenance management practices which are likely to improve their operational performance and increase the level of application of those practices. The stations' top management should also increase their level of support, especially on the human factor.

It is also recommended that, to deal with the highest challenge of delay in spares delivery as maintenance management is concerned, the stations should engage in spares delivery contracts. The study revealed that only two-(2) stations had 1 - 2 years spares supply contracts. It is paramount to have such contracts with the equipment original manufacturers. Such contracts should have delivery periods in line with maintenance schedules. Just-in time spares delivery to solve the challenge of delay in spares delivery is also recommended. It is also important for the top management of the stations to implement measures aimed at addressing the other reviewed challenges. Such measures should include training of staff, reducing maintenance costs from current levels and providing funds and time required to execute preventive and corrective maintenance.

REFERENCES

Alsyouf, I. (2007). The role of maintenance in improving Companies' productivity and profitability: *International Journal of Production Economics, 105* (1), 70 – 8.

Al-Turki, A. (2011). Methodology and Theory: A framework for strategic planning in maintenance. *Journal of Quality in Maintenance Engineering* Vol. 17 No. 2, pp 150-162.Retrived from **www.emeraldinsight.com/1355-2511.htm**.

Al-Turki, U. (2011). Methodology and Theory: A framework for strategic planning in maintenance. *Journal of Quality in Maintenance Engineering, 17*(2), 150-162.

Armstrong M. (2000). *Strategic Human Resource Management*. 2nd Ed.

Barney, J.B. (2011). Firm Resources and Sustained Competitive Advantage. *Journal of management, 17*(1), 99-120.

Barney, J.D. (1991). Firm Resources Sustained Competitive Advantage. *Journal of Management* 99- 120.

Ben-Daya, M. and Duffaa, S.O. (1995). Maintenance and Quality: The Missing Link, *Journal of Quality in Maintenance Engineering, 1* (1), 20-6.

Betts P.W. (1989). *Supervisory study: A management perspective*. 5th Ed. (pp 536- 538).

Bryman, A., & Bell, E. (2007). *Business Research Methods* (2nd Ed.): Oxford University Press.

Buchanan, D., & Besant, J. (1985) Failure uncertainty and control: The role of operators in a computer integrated production system. *Journal of Management Studies, 22*(3), 282- 308.

Campbell, J.D and Jardine, A.K. (2001). *Maintenance excellence*, Marcel Dekker, New York: NY.

Campbell, J.D. (1995). Outsourcing maintenance management: A valid alternative to self provision. *Journal of Quality in Maintenance Engineering, 1*(3), 18- 24.

Coase, R.H. (1937). *The Nature of the Firm.* Economica.

Cole G.A (2004*). Management theory and practice*, G.A Cole. Sixth Edition, published by Thomson Learning.

Dilworth, J.B. (1992). *Operations Management*: Design, Planning and Control for Manufacturing and Services: McGraw-Hill, INC.

Douglas, A. (2012). [Sigma Six seminar notes]. Nairobi: Intercontinental Hotel.

Eliyahu M. G. (1984). *THE GOAL: A process of ongoing improvement*. 1st Edition. North River Press.

Hassanain, M., Froese, T., & Vainer D. (2001). Development of maintenance management: Artificial Intelligence in Engineering, 15, 177-93.

Hennequin, S., & Arango, G. (2009).Optimization of imperfect maintenance based on fuzzy logic for single-stage singe-product production system: *Journal of Quality in Maintenance Engineering*, *15* (4), 412 – 429.

Hipkin, I.B. and De Cock C. (2000). *TPM and BPR: Lessons for maintenance management*, 28, 277-92.

Jasper, V., Hans, W., & Warse, K. (2011). Methodology and Theory: Typology of condition based maintenance. *Journal of Quality in Maintenance Engineering*, *17* (2), 183-202. Retrieved from www.emeraldinsight.com/1355-2511.htm.

Khan, M.R., & Darrab, I.A. (2010). Reviews and Case Studies: Development of Analytical Relation between Maintenance, Quality and Productivity. *Journal of Quality in Maintenance Engineering*, *16*(4), 341-353.Retrieved from **www.emeraldinsight.com/1355-2511.htm**, New Delhi-110001.

Kothari, C.R. (2004). *Research methodology: Methods and Techniques,* 2nd Edition. New Age international (P) Publishers.

Ludwig, G., & Pemberton, J. (2011). A Management Perspective of Dynamic Capabilities in Emerging Markets: The Case of Russian Steel Industry. *Journal of East European Management Studies 16* (3) , 215- 236.

Marquez, A.C., Leon, P.M., & Campos, M.L. (2009). The Maintenance Management framework: A practical view to maintenance management. *Journal of Quality in Maintenance Engineering*, 15(2), 167-178.Retrieved from www.emeraldinsight.com/1355-2511.htm.

Marquez, C.M., & Gupta, J.N (2005). Contemporary maintenance management: Process, framework and supporting pillars. *The International Journal of Management Science, Omega* 34 (2006), 313-326. Retrieved from www.sciencedirect.com

Marseguerra, M., Zio, E., & Podofillini, L. (2002). Condition based maintenance optimization by means of generic algorithm and Monte Carlo simulation*: Reliability Engineering & System Safety. 77*(1), 151-166.

Matuga H. (2013).*Contribution of TPM strategy to the competitive advantage of Unilever Kenya Ltd*. Unpublished MBA Thesis; University Of Nairobi.

Mills, G., Standingford, O., & Appleby R.C. (1986). *Modern Office Management* (7^{th} Ed.).128 Long Acre, London: Pitman Publishing Ltd.

Ministry of Energy & Petroleum (2013-2016). *Kenya Investment Prospectus*. Kenya Vision 2030: 5000 + Mw by 2016; Power to transform Kenya.

Moubray, J. (1997). *Reliability centered maintenance*, 2nd Ed., Butterworth-Heinemann, Oxford.

Mugenda, O.M. & Mugenda, A.G. (1999). Research Methods: Quantitative and Qualitative Approaches. Nairobi, Acts Press.

Muhleman, A., Oakland, J., & Lockkyer, K., (1998). *Production and operations management* (6^{th} ed.).University of Bradford, 128 Long Acre, London: Pitman.

Mulwa L.(2000).*Operation Management Techniques In Maintenance Management: A case study of the Kenya Railways Workshop*. Unpublished MBA Thesis; University Of Nairobi.

Mwanyota, J. (2011). [Strategic Quality Management Lecture Notes]. Uniplaza, Mombasa: University of Nairobi.

Naylor, J. (1996). *Operations Management*. 128 Long Acre, London: Pitman publishing.

Ng'era S.(2013). *How Maintenance Practices Influence Manufacturing Performance in KTDA managed Factories*. Unpublished MBA Thesis; University Of Nairobi.

Ngatia G. (2013). *Maintenance practices and power Plants operational performance in Kenya*. Unpublished MBA Thesis; University Of Nairobi.

Njoroge, E. (2010). KenGen's Good to Great Technical Seminar: *Opening Remarks*. Safari Park Hotel, Nairobi.

Oganga M. (2013.*Performance Measurement Practices and Maintenance Improvement among Coca Cola Bottling Plants in Kenya,*. Unpublished MBA Thesis; University Of Nairobi.

Palmer, R.D (1999). *Maintenance Planning and Scheduling*. McGraw-Hill, New York: NY

Pannerrselvam , R. (2009). *Production and Operations Management* (2^{nd} ed.). PHI Learning Private.

Pintelon, L.M and Gelders, L.F (1992). Maintenance management decision making. *European Journal of Operational Research*, Vol. 58, 301-17.

PPA (2009). Power Purchase Agreement: An Agreement between Kenya Electricity Generating Co. Ltd and The Kenya Power & Lighting Co. Ltd.

Sharma, A. & Yadava, S.G. (2011). Reviews and Case Studies: A literature review and future perspectives on maintenance optimization. *Journal of Quality in Maintenance Engineering, 17*(1), 5- 25.

Simoes, J.M., Gomes, C.F., & Yasin, M.M. (2011). Reviews and Case studies: A literature review of maintenance performance measurement: A conceptual framework and directions for future research. *Journal of Quality in Maintenance Engineering 17* (2), 2011 pp.116-137. Retrieved from www.emeraldinsight.com/1355-2511.htm.

Smith, R. (2003). Best Practices: Maximizing Maintenance Management. *Maintenance & Operations Article.*

Spencer, J.W. (2003). Firms Knowledge Sharing Strategies in Global Innocation System: *Strategic Management Journal 24* (3) 217-233.

Tsang, A., Jardine, A. and Kolodny, H. (1999). Measuring maintenance performance: A holistic approach. *International Journal of Operations & Production Management, 19*(7), 691-715.

Vanneste, S.G and Wassenhove, L.N. (1995). An integrated and structured approach to improve maintenance. *European Journal of Operational Research*, Vol 82, 241-57.

Veldman, J., Wortmann, H., & Klingenberg W., (2011).Methodology and Theory: Typology of condition based maintenance. *Journal of Quality in Maintenance Engineering, 17*(2), 183- 202.

Visser, J.K., (1998).Maintenance management: An appraisal of current strategies, ICOMS 98, Paper 031. Retrieved from **www.emeraldinsight.com/1355-2511.htm**.

Wen-Jinn, C. (2010).Methodology and Theory: Minimizing completion time with maintenance schedule in a manufacturing system. *Journal of Quality in Maintenance Engineering*, 16(4), 382-394. Retrieved from www.emeraldinsight.com/1355-2511.htm.

Wild, R. (2002). *Operations Management*. Sixth Edition. 11 York Road, London: Continuum.

Wireman, T. (1998). Developing performance indicators for managing maintenance, industrial press, New York: NY.

APPENDICES

APPENDIX 1: FORMULAE FOR CALCULATING OPERATIONAL PERFORMANCE

Production = Total electrical power output/generation (Murthy, 2005)

Productivity = $\frac{Output}{Input\ element}$ (Murthy, 2005)

Human productivity = $\frac{Output}{Human\ Input}$ (Murthy, 2005)

Material productivity = $\frac{Output}{Material\ \ Input}$ (Murthy, 2005)

MTBF= $\frac{Total\ running\ time}{Number\ of\ failures}$ (Panneerselvam, 2009

Total productivity = $\frac{Total\ Output}{Total\ \ Input}$ (Murthy, 2005 & Panneerselvam, 2009)

Availability = $\frac{MTBF}{MTBF+MTTR}\ x\ \ 100\%$ (Oakland & Lockkyer, 1992).

Availability = $\frac{up\ time}{Down\ time\ +Up\ time}\ x\ \ 100\%$ (Hennequin and Arango, 2009)

Efficiency =$\frac{output}{input}$ (Murthy, 2005)

Efficiency = $\frac{Actual\ Output}{Expected\ or\ standard\ output}$ (Murthy, 2005)

Reliability=$\frac{Number\ of\ Units\ still\ in\ operation\ after\ \ time\ t}{Number\ of\ Units\ in\ operation\ initially\ at\ time\ t=0}$

(Oakland & Lockkyer, 1992).

Value= Cost proportionate to the function

= $\frac{Function\ or\ Utiliy}{Cost}$ (Murthy, 2005)

APPENDIX 2: POPULATION OF STUDY

S/no.	Power Station	Location	Installed capacity (Mw)	Mode of electricity generation	Firm owning the Station
1.	Embakasi Gas Turbine	Nairobi	54	Gas turbine	KenGen
2.	Garissa	Garissa	6	Diesel	KenGen
3.	Gitaru	Lower Tana	225	Hydro	KenGen
4.	Gogo	South Nyanza	2	Hydro	KenGen
5.	Iberafrica	Nairobi	108	Diesel	IPP
6.	Kamburu	Lower Tana	94.2	Hydro	KenGen
7.	Kiambere	Lower Tana	168	Hydro	KenGen
8.	Kindaruma	Lower Tana	72	Hydro	KenGen
9.	Kipevu I	Mombasa	73.5	Diesel	KenGen
10.	Kipevu III	Mombasa	120	Diesel	KenGen
11.	Lamu	Lamu	2.7	Diesel	KenGen
12.	Masinga	Lower Tana	40	Hydro	KenGen
13.	Mesco	Upper Tana	0.38	Hydro	KenGen
14.	Ndula	Upper Tana	2.0	Hydro	KenGen
15.	Ngong	Ngong	5.1	Wind	KenGen
16.	Olkaria I	Naivasha	45	Geothermal	KenGen
17.	Olkaria II	Naivasha	105	Geothermal	KenGen
18.	Olkaria IV	Naivasha	140	Geothermal	KenGen
19.	OrPower Kenya	Naivasha	110	Geothermal	IPP
20.	Rabai Power	Mombasa	90	Diesel	IPP
21.	Sagana	Upper Tana	1.5	Hydro	KenGen
22.	Sang'oro	Nyanza	21	Hydro	KenGen
23.	Sondu Miriu	Nyanza	60	Hydro	KenGen
24.	Sosiani	Eldoret	0.4	Hydro	KenGen
25.	Tana	Upper Tana	20	Hydro	KenGen
26.	Tsavo Power	Mombasa	74	Diesel	IPP
27.	Turkwel	West Pokot	106	Hydro	KenGen
28.	Wellhead	Olkaria	5	Geothermal	KenGen
29.	Wanjii	Upper Tana	7.4	Hydro	KenGen
Total installed capacity			**1,758.18**		

Source: KenGen Diary (2014) and Kenya Investment Prospectus (2013- 2016).

APPENDIX 3

PART A: INTRODUCTION LETTER

Julius M. Kamau
Olkaria 1 Power Station
P.O. Box 475
Naivasha
October 2014

Dear Sir

RE: <u>REQUEST FOR RESEARCH DATA</u>

I am a post graduate student of School of Business, University of Nairobi majoring in Operations Management. My special area of interest is the application of maintenance management practices to spur operational performance. In this respect, I am conducting a Management Research Project on the theme." Maintenance management practices and operational performance in Electricity Generating Stations in Kenya.

In order to undertake the research, you have been selected to form part of this study. This is therefore to kindly request for your assistance in answering questions in the attached questionnaire as honestly and accurately as you can. The information you provide will be treated with utmost confidence and is needed purely for academic purposes only.

Your kind assistance and co-operation will highly be appreciated.

Yours faithfully,

………………………………… ………………………………

Julius M. Kamau **Dr. James Njihia**

(Student) **Senior Lecturer**

Dept of Management Science

PART B: QUESTIONAIRE

SECTION 1: PRELIMINARY INFORMATION

Kindly take you time to feel this Questionnaire. This is to enable me complete by MBA Project. Your feedback will highly be appreciated. All responses will be treated with utmost confidentiality. The Questionnaire is meant to gather information/ data as pertains '***Maintenance Management Practices and operational performance in the Electricity Generating Stations'*** for academic purposes only. In the project Report, power Stations will simply be referred as PS1…….PSn. Put an **'X'** against your response.

SECTION 1: PRELIMINARY INFORMATION

1. **What is your gender?**
   Male ( ) Female ( )
2. **What is your designation at your power station?**
   a) Technician ( ) b) Superintendant ( ) c) Engineer ( ) d) Chief Engineer ( )
3. **What is your age bracket?**
   a) Below 30 years ( ) b) 31 – 40 years ( ) c) 41 – 50 years ( ) d) above 50 years ( )
4. **How many years have you worked at your current power station?**
   a) Less than 2 years ( ) b) 2- 5 years ( ) c) 5 - 10 years ( )
   d) 10- 15 years ( ) e) above 15 years ( )
5. **What is the mode of electricity generation at your station?**
   Hydro ( ) b) Geothermal ( ) c) Diesel ( ) d) Gas Turbine ( ) e) Wind ( )
6. **What is the name of your power Station, operating and installed capacities?**
   Name................................ Operating capacity……..Mw Installed capacity……….Mw
7. **For how many years has your power Station been running up to date?**
   a) Less than 2 years ( ) b) 2- 5 years ( ) c) 5 - 10 years ( )
   d) 10- 15 years ( ) e) more than 15 years ( )
8. **How many power generating machines are installed at your station?**
   a) 1- 2 ( ) b) 3 – 4 ( ) c) 5 – 6 ( ) d) 7 – 8 ( ) e) More than 8 ( )
9. **What is the rate of breakdowns occurrence at your Station?**
   5) Very high ( ) 4) High ( ) 3) Medium ( ) 2) Low ( ) 1) Very Low ( )

10. What has been the average monthly sustained plant's time based availability of your Station in the last one year?

a) Below 60% ( ) b) 60 % to 75 % ( ) c) 75 to 85% ( )

d) (85 to 90 %) ( ) e) 90 % to 95 % ( ) f) above 95% ( )

11. Do you have Spare parts supply contract (s) for your maintenance jobs?

No ( ) yes ( )

12. If yes, what is the duration of your spare parts supply contract (s)?

a) 1 – 2 years ( ) b) 3- 4 years ( ) c) 4 – 5 years ( ) d) More than 5 years ( )

13. In your Station, are there some maintenance staff who are on time based labour contracts?

No ( ) Yes ( )

14. How would you rate the operational performance of your Station for the last one year?

5) Very good ( ) 4) Good ( ) 3) Average ( ) 2) Poor ( ) 1) Very poor ( )

15. At your Station, what is the estimated percentage of total maintenance costs in relation to the total Station's costs?

a) 10 % - 20 % ( ) b) 20 % -30 % ( ) c) 30- 40% ( )

d) (40 - 50 %) ( ) e) above 50 % ( )

SECTION 2: MAINTENANCE MANAGEMENT PRACTICES

1. In a score of out of 5: 5 *being 'Very high', 4' High'*, 3: '*Average*', 2: 'Low' 1: Very Low

How would you rate the <u>extent of application</u> of the following maintenance management practices at your Station?

s/no	**FACTOR**	**5 (Very high)**	**4 (High)**	**3 (Average)**	**2 (Low)**	**1 (Very Low)**
1)	Condition Based Maintenance **(CBM)**					
2)	Preventive Maintenance **(PM)**					
3)	Scheduled Maintenance **(SM)**					
4)	Productive Maintenance **(PM)** (small scale maintenance by Operations/ shift Staff)					
5)	Reliability Centered Maintenance **(RCM)** (prioritizing jobs based on impending risks)					
6)	Quality or 'Tune up' or production Improvement Maintenance **(QM)**					
7)	Computer Based Management Maintenance (CBMM) or System Work Orders maintenance **(WOM)**					
8)	'Run to failure' Maintenance **(RTFM)** (wait for failure to occur (based on some reasons e.g. economics, lack of outage), then do maintenance					
9)	Breakdown Maintenance **(BM)** (repair of breakdowns)					
10)	Predictive Maintenance **(PDM)** (Based on analysis of operating fluids and physical observations e.g. change of oil colour, contaminants in oil, vibrations, noise level increase etc)					
	Please if any other maintenance management practices used in your station, list and rate its level of application					
11)						
12)						

SECTION 3: TOP MANAGEMENT SUPPORT FOR MAINTENANCE FUNCTION

1. **In a score of out of 5: 5** being 'Very High', 4 'High', 3:'Average' , 2:'Low' 1:'Very Low')

How would you rate the level of top <u>management support</u> for maintenance function in your Station in regards to the following aspects?

S/no	**FACTOR**	5	4	3	2	1
		(Very High)	**(High)**	**(Average)**	**Low**	**Very Low**
1)	Provision of motivation					
2)	Provision of technical training					
3)	Provision of allowances (risks, standing, extraneous allowances etc)					
4)	Provision of modern tools / equipment					
5)	Provision of experts diagnostic /trouble shooting Systems					
6)	Level of maintenance staffing					
7)	Provision of opportunities for bench marking with best practices/ other similar organization					
8)	Recognition of work performance					
9)	Presence of performance based rewards/incentives					
10)	Adequate budgetary allocation					

2. **In a score of out of 5: 5 '**being Very High', 4 'High', 3 : 'Average' , 2 'Low' 1: 'Very Low')

How would you rate the <u>level of impact</u> of the following factors on the general performance of the maintenance function at your Station?

S/No.	**Factor**	**5**	**4**	**3**	**2**	**1**
		(Very high)	**(High)**	**(Average)**	**(Low)**	**(Very Low)**
1)	Processes and maintenance strategies in use					
2)	Level of Staff skills and competencies					
3)	Lack of work incentives and recognition					
4)	Spares availability					
5)	Tools in use					
6)	Manpower available					

SECTION 4: MEASURES OF ORGANIZATION'S OPERATIONAL PERFORMANCE

1. In a Likert scale of out of 5: 5 being 'Always achieved', 4'most times achieved ',

3: 'Sometimes achieved', 2 'Rarely achieved' 1: 'Never achieved'

Please rate the <u>extent of achievement</u> of the following targets at your power Station. If it is not part of your operational target, please write 'N' in any column against the indicated target.

No	**FACTOR**	**5**	**4**	**3**	**2**	**1**
		Always achieved	**Most times achieved**	**Sometimes achieved**	**(Rarely achieved)**	**(Never Achieved)**
1)	Performance availability					
2)	Fuel efficiency (Kg/Kwhr), ***for diesel Stations***					
3)	Specific lubrication Oil consumption (g/Kwh)					
4)	Non-occurrence of accidents (Number /month)					
5)	Maintenance cost per unit generated (Kshs/Kwh)					
6)	Means Time to Repair (MTTR)/ Staff productivity rate					
7)	Mean Time to Failure (MTTF)					
8)	Minimum planned outage counts/month					
9)	Maximum forced outage counts/month					
10)	Number of work orders closed/month					
11)	Total units generation/month					
12)	Maximum breakdown hours/Month					
	Please, if any other, list and rate					
13)						
14)						

2. In a score of out of 5: **5 '**being Very High', 4 'High', 3 : 'Average' , 2 'Low' 1: 'Very Low')

How would you rate the <u>level</u> of use of the following <u>inputs</u> into your Station's maintenance activities?

S/no.	**FACTOR**	**5 (Very high)**	**4 (High)**	**3 (Average)**	**2 (Low)**	**1 (Very Low)**
1)	Staff labour (Overtimes and other allowances e.g. dinners and lunches)					
2)	Spares					
3)	Materials (e.g. Cotton rags, grease, lube oil and cleaning fluids e.g. kerosene)					
4)	Fuel Oil (**for Diesel Stations only**)					
5)	Chemicals					
6)	Technical /skills upgrade Training					
7)	External services e.g. contracting of jobs					

3. How would you rate the <u>level</u> of the following <u>outputs</u> at your Station's as a result of your maintenance activities

S/no.	**FACTOR**	**5 (Very high)**	**4 (High)**	**3 (Average)**	**2 (Low)**	**1 (Very Low)**
1)	Sustained availability					
2)	Production/ generation maximization					
3)	Value addition (e.g. sustainability, increased mean time to failure , low production cost per Mwh etc)					
4)	Plant reliability					
5)	Overall plant operation costs reduction					
1)	Efficiency of the machines / production					

SECTION 5: CHALLENGES OF MAINTENANCE MANAGEMENT

1. How would you rate the level of the following challenges as regards maintenance management at your Station? Use an 'X' for your choice.

No	FACTOR	5 (Very high)	4 (High)	3 (Average)	2 (Low)	1 (Very Low)
1)	Delayed deliveries of Spares					
2)	Lack of enough funds to carry out proper maintenance					
3)	Lack of sufficient plant and process knowledge					
4)	Lack of historical data					
5)	Lack of sufficient maintenance time					
6)	Lack of top management support					
7)	Fear of disruptions in productions and operations thus delaying in maintenance programs					
8)	Frequent breakdowns					
9)	Environmental regulations and limitations					
10)	Inadequate technical training of maintenance personnel					
11)	Procedures e.g. in procurement and spares acquisition from the Stores					
12)	Use of outdated Tools					
13)	Costs over runs (high maintenance costs)					
	Please list any other and rate accordingly					
14)						
15)						

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This is the last page of the Questionnaire...thanks so much for your time