OPERATIONAL CHALLENGES FACING PERFORMANCE OF THERMAL POWER PLANTS IN KENYA

BY

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DECLARATION

a) Student Declaration.

This project is my original work and has not been submitted for any award of Degree in any other University or institution for any other purpose.

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b) Supervisor Declaration

This research project has been submitted for examination with approval as the University Supervisor

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DEDICATION

My special dedication goes to my family, the Kuria’s,

Wife

Grace W. Kuria

Children

Michelle N. Kuria, Hillary M. Kuria and Hadassah W. Kuria.

As I embarked on this noble course, you were the force behind. I found purpose in life to give you the best

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Praise the LORD, Who in His infinite mercy guided me to the completion of this MBA project report. *'I will praise you, O LORD, with my whole heart; I will tell of all your marvelous works'. (Psalm 9:1)*

My wife Grace Kuria and children. Thanks very much for your support, sacrifice and prayers. I felt a King. I prophesy greater heights over your lives. May God guide your paths.

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My sincere prayers shall always be with you all.

Moses Kuria
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ABSTRACT

The advent of thermal generation of electricity dates back in back in 1996 when aid embargo was imposed in the country a time when draught had almost crippled the economy due to dwindling of hydro power plants to les than 20%. That was the critical time in the history of Kenya owing to the fact electricity cuts across all the three pillars as contained in the vision 2030 blue print. To date, seventeen years of thermal energy generation has not been an easy journey. This is characterized by the frequent regional and national blackouts. Generation business is guided by the power purchase agreement a binding document that contains the key pillars that measures performance. This study sought to establish the operational challenges that affect performance of thermal power plants in Kenya. It was guided by a single objective which was to examine the operational challenges in thermal power plant. The study employed a descriptive research design. The population consisted of six thermal power plants in Kenya as listed in appendix IV as provided by the MoE. The study targeted two relevant departments which are operations and maintenance of which six respondents was sought on each as follows, one departmental manager, two engineers and three supervisors totaling to six hence making twelve respondents in the two departments. A total of seventy two respondents were targeted. The response rate was a phenomenal 100% male which was 71.94 % (59 respondents out of targeted 72). In the survey six crucial variables were exhaustively analyzed namely (reliability, utilization factor, quality, cooling water, spares acquisition and efficiency). Reliability and utilization factor were seen to be the biggest challenges affecting the performance of thermal power plants. Quality, cooling water and efficiency were seen to be strong practices that promote performance. It was recommended that more studies be done to focus on how the national grid can be developed and also craft and subsequent review the power purchase agreement since all are external factors that directly affect performance of the generating companies. Some companies were seen to have generation reserve and others did not. This area also requires further research on how performance is affected in line with generation sector. Owing to the findings of the research it was suggested that future studies be done to include hydro, geothermal wind and solar power generation. Also fundamentally, a future study be done on effects of monopoly of purchase of bulk power. Future studies should also consider expanding the topic to include moderating variables like equipment useful life and environmental factors.

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ABBREVIATIONS AND SYNONYMS

AGO	Automotive Gasoline Oil
CG	Centralised Generation
DG	Distributed Generation
ERC	Energy Regulatory Commission
IPP	Independent Power Producer
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KETRACO	Kenya Transmission Company
KPC	Kenya Power Company
KW/h	Kilowatt per hour
LCPDP	Least Cost Power Development Plan
MoE	Ministry of Energy
NITA	National Industrial Training Institute
NO_x	Nitrogen Oxide Emissions
PPA	Power Purchase Agreement
RD&D	Research Development and Design
RER	Renewable Energy Resources
SCADA	Supervisory Control and Data Acquisition
SFOC	Specific Fuel oil Consumption
SGCC	Smart Grid Consumer Collaborative
SLOC	Specific Lube oil Consumption
TPP	Thermal Power Plant
TQM	Total Quality Management
UoN	University of Nairobi
USA	United States of America

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

This chapter provides background to the proposed study, definition of key concepts, statement of the problem and research objectives. The chapter also contains justification for the study and outline. This study was poised to investigate the operational challenges facing performance of thermal power plants (TPP) in Kenya.

The term 'Thermal Power' refers to energy produced from fossil fuel using low speed heavy diesel engines. This mode of power is obtained through conversation of chemical energy inherent in the fuel into electrical energy by mechanical means of reciprocating engine. According to Prada, (1999), energy generated is delivered practically on real time and there is no convenient method to store it. This makes necessary to maintain a continuous and almost instantaneous balance between production and consumption of electricity in power systems. Generation margins are attained by providing stand-by plant capacity and they represent reserves of generation capacity that can be rapidly utilized in case of a supply shortage. Modern power generation is complex system highly integrated and very complex systems namely, fuel oil, lube oil, compressed air, exhaust, cooling, instrumentation and fuel storage. Generation is divided into three functional areas that can be analysed separately, namely generation, transmission and distribution (Prada, 1999). However, these systems cannot stand independently. All power producers fall under the third category which is the generation. In Kenya, energy produced is directly injected to the national grid where it is transmitted and distributed for consumption by the industries, institutions and households.

The advent of thermal power plant operated by Independent Power Producers (IPP) dates back in 1996 when the country experienced power shortage due to draught that nearly crippled the economy of the country (Wainaina & Kagiri. 2009). Hydro Power stations that Kenya depended on had dwindled to almost 20% output (Wambugu, 2010) a time when aid embargo was imposed on the country between 1991-1995. The effect resulted to capital shortfall on generation capacity, weak transmission and distribution network system. That was the darkest period in the economy of the country characterised by blackouts and expensive replacement with emergency power. The impact caused economic downturn with apparent inefficiency in electricity sector (Ciano, 2006). The revolution resulted to quick establishment of TPP that saw the ingress of Westmont Power, Iberafrica Power and Agrreko Power into the energy arena. The imbalance offered opportunities for sustainable energy integration through the participation of independent power producer (IPP) in the country. Since then, the sector has welcome more players i.e. Kipevu Power Plant and Tsavo Power, Rabai Power both in the County of Mombasa. Thika Power is newly established and two more are under construction in Arthi River called Trump and Gulf Power (MoE, Website). The growth is also due to Energy Regulatory Commission (ERC) initiative to develop electricity under low cost power development plan (LCPDP) strategy a move that will increasingly see IPPs presence in meeting shortfall in the country. Despite sector expansion and subsequent electricity output in the country, the national grid remains underdeveloped. The current status cannot adequately serve the ever growing demand. All the power plants are centralised generation with manual controls at the substations (KPC, Website). Besides Kipevu power station which is a parastatal, the other thermal power plants are private owned hence called Independent Power Producers (IPP) with international ownership and bound by the power purchase agreement (PPA) which defines the rules of engagement. In TPP, 90% is Mechanical and 10% electrical.

A common feature in thermal power plants is noise caused by the reciprocating effect of pistons in the generation process, indicator that operations are normal. Silence is an indicator of challenges to the investor and the power plant management. Many management teams invest a lot of time and effort into analysing environment capabilities and services to develop their strategy. Occasionally they forget to scan the outer environment that affects their performance. Experiences indicate that power generation is not only an internal challenge but also external. A fresh look at log sheets, generation dispatch, maintenance records, service reports and management review reports amongst others will reveal evidence of operational draw backs (Wanyiri, 2010). Not to mention electrical and mechanical failures, quality issues, regulatory issues, human resource issues, spares concern, environmental conditions, and operational challenges etc. occurrence of any of these results into operational challenges.

According to the (PPA) metered electricity transmitted is charged in KW/h. Total electricity metered in KW/h is multiplied by the standing amount plus availability charges and that constitutes the revenue. Profit for the business is a factor of fuel consumed per KW/h a fuel transfer cost. In an event more fuel is used to generate electricity, it means that losses are incurred therefore need to optimize operation efficiency On this regard systems efficiency are critical for running a power plant. By design the fuel constitutes 75% of total cost (HSBIC, 2008). Therefore close monitoring of fuel used in production of a kilowatt hour electricity is called specific fuel oil consumption (SFOC).

1.1.1 Operational Challenges in Thermal Power Plants in Kenya

Operations challenges in power plants are synonymous to challenges by consumers. Despite power poverty in Kenya, explained and unexplained shortages affect the development of a Nation. Mwangi (2013) explains the electric reason why vision 2030 may be achieved seventy five years late in 2105. He attests the reason to vandalism, continued use of old grid system and lack of thread in between the players in the power industry.

To date energy sector has experienced a paradigm shift from external work force dependency to local in running and maintenance of the power plant. Before the ingress of the technology, technical work was deemed as a preserve of the whites, locals assumed the role of helpers. Seventeen years later between (1996-2013) thermal generation in Kenya has qualified engineers, technicians plant controllers, auditors and consultants. This is evident with introduction of customised training at the local institutions, example of Jomo Kenyatta University of Agriculture and Technology (JKUAT, Website) currently offering marine engineering, University of Nairobi (UoN, Website) offering Master of Science in Energy Management and also a number of students who secure industrial training at the power plants through Directorate of National Industrial Training Authority (NITA Website).

As theory defines TPP operations strategy is defined in three levels. First is the strategic reconciliation, secondly sustainable advantage (sustainability) and thirdly impact and uncertainty (Magutu, Mwove & Ndubai, 2010 in Nigel and Lewis, 2007). To integrate the three, requires policies that will see performance realised in the organisations. Despite many organisation adopting operation management tools, challenges still characterise this sector. According to operations management, decision areas like process and capacity design, quality, maintenance, design of goods and services facility location amongst others have been implemented (Render & Heizer, 2009) and are vital in thermal generation. Challenges still threaten these organisations and so is a phenomenon in many other.

A study in Latvia by Barkans & Zalostoba (2009) revealed that, in the 1960-1970s electricity black outs was a common occurrence attributable to increase in players in the generation leading to grid overloads. Such blackouts led to damaged equipment of power plants, interrupted production cycles, chaos in customers and great economic losses. Wanyiri (2010) in his study did an assessment of TQM practices in TPP. He sought to assess systems improvement, leadership and management practices, quality entrenchment, customer involvement in decision making. His findings revealed high level of TQM practices at all levels in all TPP an effective indicator of performance.

According to Kerekezi & Waeni (2005) argued that, Kenyan grid constitutes to a large portion of operational challenges in the TPP. Power thefts, illegal connections and poor distribution characterize the grid. Interference with the transformers destabilized the grid leading to outages. The findings also suggested adoption of distributed generation (DG) system which would lead to mini-grid system, a solution to numerous blackouts. Statistics also reveal that with installed capacity of 1350 MW only 28.65 % of population has access to the national grid (Nyakundi, 2011). According to World Bank, less than 20 % of the total population and 5% of the rural population in Kenya has access to electricity (World BANK, 2009) yet is the ingredient of modern civilization (Agboola, 2011).

Business operation in TPP is guided by Power Purchase Agreement (PPA), a contract to buy bulk electricity generated by a TPP (MoE, 2013). The agreement is critical part of planning a successful thermal power generation because it secures a long-term stream of revenue for the project through the sale of bulk electricity generated. TPP is made of complex structures, immense activities, systems, procedures in the generation of electricity, the performance therefore becomes a subject of many parameters. PPA stipulates buying of electricity in Kw/h. Contract entails purchase of total units generated. Any consumption above the standard translates to losses and below translates to profits. By design fuel constitutes 75% of total cost (HSBIC, 2008). Therefore production is a measure of specific fuel oil consumption (SFOC) to generate a KW /h of electricity.

Smooth operation of TPP reflects on revenue streams. However, challenges are numerous from technical to human. High level of work execution is a first to none. Generation is through automated system where all parameters are captured through supervisory Control and data acquisition (SCADA) from which trends are analyzed for technical and managerial decision making.

1.2 Statement of the Problem

Currently, the biggest question in TPP is where the competitive advantage is owing to the fact there is unmet demand (World BANK, 2009). Electricity cannot be segmented since the grid is common, units of measure are the same and availability conditions are the same. Until when Electricity penetration has reached its full capacity, then the strategies applicability is uncertain.

Since the advent of thermal power generation in Kenya, now translates to seventeen years. It is not easy to comment on the learning curve experience since no study has been done on that area. Wanyiri, (2010) in his study did an assessment of TQM practices in TPP where he sought to assess systems improvement, leadership and management practices, quality entrenchment, customer involvement in decision making. His findings revealed high level of TQM practices at all levels in all TPP an effective indicator of performance. However, his study did not focus on the challenges affecting thermal power plant

This research also did not focus on the challenges facing TPP. Grid problems have been established in many studies as reason that affects performance of TPP. Wainaina, (2013) revealed failures to weak distribution network characterized by limited redundancy and aging installations. Momoh, et al (2012) in his study also connected challenges of TPP on grid problems, a study that culminated into a ninth paper. In all these, none specifically focuses on thermal power generation hence other challenges have not been studied

For the forgoing analysis it seems there is no scholarly research on operational challenges affecting performance of thermal power plant has been attempted. Therefore to be able to respond to the operational challenges, it is instructive to investigate and understand the operational challenges by answering the following question. What are the operational challenges facing performance of thermal power plants in Kenya?.

1.3 Objectives of the Study

Thus the research objectives of this study will be:

To determine the Operational challenges affecting performance thermal power plants in Kenya

1.4 Value of the Study

The study is expected to contribute in the following ways.

To the shareholders. It will help in decision making in terms of investments to engage in and crafting vision for future investment particularly in the power purchase agreement.

To the management. Will help in focusing their efforts towards their competitive areas while seeking solutions to the weak areas.

To the academics and scholarly work. Will help in opening up further research in the areas of thermal power plant

To the Government. Will help in assisting players in the thermal power generation in terms of capacity building, negotiation of power purchase agreement.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to present a state of art metrics and challenges experienced in TPP therefore affecting core business which is to operate and maintain the generation units. The review will discuss the experiential challenges by the researcher in a thermal power TPP.

2.2 Performance Metrics in Thermal Power Plants

Performance in TPP is defined by a set of metrics i.e. reliability, utilisation factor, quality, cooling water, spares procurement and efficiency under the specified conditions. A Thermal Power Plant is a complex engineering system which provides electric power for domestic, commercial, and industrial use. These metrics may cause shut down of the plant or reduce the generation of power resulting in load shedding and many other problems including lose of productive activities (Tewari, Kajal & Khannduja, 2012). For improving the productivity the metrics of systems/subsystems in operation must be maintained at highest order. To achieve high production goals, the systems should remain operative (run failure free) for maximum possible duration. But practically these systems are subjected to random failures due to poor design, wrong manufacturing techniques, lack of operative skills, poor maintenance, overload, delay in starting maintenance and human error etc. These causes lead to non-availability of an industrial system resulting into improper utilization of resources (man, machine, material, money and time). So, to achieve effective performance there should be close monitoring and mitigation of these metrics.

2.3 Challenges in Thermal Power Plants

Operation Challenges are discussed in different perspectives. (Seymour, 2001) in white paper claims many power problems originate in the commercial power grid, with its thousands of miles of transmission lines subject to weather conditions such as hurricanes and lightning storms along with equipment failure, traffic accidents and major switching operations. Also, power problems affecting today's technological equipment are often generated locally within a facility from any number of situations, such as local construction, heavy start-up loads and faulty distribution components. The challenges are discussed below.

2.3.1 Reliability

According to (Prada, 1999, Moubray, 2007) the term reliability is broad in meaning. In general, reliability designates the ability of a system to perform its assigned function, where past experience helps to form advance estimates of future performance. Reliability can be measured through the mathematical concept of probability by identifying successful performance with the degree of reliability. Generally, a device or system is said to perform satisfactorily if it does not fail during the time of service. On the other hand, a broad range of devices are expected to undergo failures, be repaired and then returned to service during their entire useful life.

The function of an electric power system is to provide electricity to its customers efficiently and with a reasonable assurance of continuity and quality. The task of achieving economic efficiency is assigned to system operators or competitive markets, depending on the type of industry structure adopted. On the other hand, the quality of the service is evaluated by the extent to which the supply of electricity is available to customers at a usable voltage and frequency (Prada, 1999). The reliability of power supply is, therefore, related to the probability of providing customers with continuous service and with a voltage and frequency within prescribed ranges around the nominal values. When the reliability of the two conditions is affected then outage presents.

Power Outage is caused by grid disturbance due to increased demand, failure of production, failure of transmission, human errors amongst others. Typically power blackouts are not caused by a single event but by a combination of several deficiencies. According to (Position Paper, 2011) argued, there is no outage known where a faultless grid collapsed completely due to a single cause. It instead pointed out on three areas as preconditions for a high power outage namely high grid utilisation (high power demand) high power plant utilisation defects due to material ageing a fact reiterated by (Agboola, 2011) on demand of electricity due to population growth and emerging industrialization. In Africa, is a factor contributing to the power outages (Eberhard & Gratwick, 2005). Sudden withdrawal of gensets from the grid causes secondary failure on engine components. Such failures are manifest in the Turbo charger and Crankshaft which are very vulnerable and expensive. Turbo charger for example is not a stock item neither the crank shaft. It therefore requires sourcing for new from the manufacturer who also does not stock. These parts are made on order. Replacement of these parts is very expensive. Offshore experts are sought as maintenance takes approximately three months for such engine to generate electricity again. As the result of the outage, ad hoc maintenance on all gensets affected in the power plant. During this breakdown the company loses on the generation. (Wainaina, 2013) attests most failures to weak distribution network characterized by limited redundancy and aging installations leading to frequent and prolonged black outs that are manually corrected.

Due to the failures as a result of grid problems, a study was done by (Momoh, Meliopolus & Saint, 2012) to evaluate the future of the grid system culminated to a ninth paper. The aim of the paper was to evaluate the relative benefits and weaknesses of centralized generation (CG) and distributed generation (DG) in the future electric grid infrastructure. The CG has been in dominant use in the legacy system, serving large consumptions of power but with a variety of problems including its cost, sustainability, and resiliency challenges in the long run. On the other hand, the DG is smaller in design and power generation, primarily designed or renewable energy resources (RER) such as wind and solar energy resources. The paper was based on the analysis of using heuristic methods and engineering judgment to determine the extent to which the economies of scale of DG and CG are used to maximize the performance of the future grid (see appendix III).

The episodes have made energy utilities in the U.S. to making significant strides in educating and engaging their customers about how to better control how much energy they use, the resulting costs they incur and the benefits of shifting their consumption. New installations and activations of Smart Meters combined with the deployment of Smart Grid infrastructure herald a new era of energy management by utilities and consumers alike.

2.3.2 Utilization Factor

Utilization of gensets in power generation is a factor that evaluates the running hours of engines during generation in terms of percentage (Heizer & Render, 2009). Waters (2006) confirms this statement by describing utilization as the proportion of designed capacity that is actually used. The higher the utilization of the gensets the better the performance in terms of share holders revenue but the lower the utilization the lower the revenue and therefore performance. TPP utilization is influenced into two ways, internal and external attributes. Power purchase agreement, is signed based on the capacity and energy charges being the larger component in the tariff. For this reason dispatch to the TPP is subject to performance of the hydro and the geothermal power plants that causes seasonal adjustments (KPC, website). During the rainy season hydro power plants perform optimally. PPA during this period will give preference to the hydro’s because a unit cost is very cheap compared to the TPP. While this season is in force, TPP are subjected to reduced load lowering utilization to as low as 30%. This is not a good scenario to the business part.

According study by (Wambugu, 2010) also noted that utilization factor of TPP is influenced by underdeveloped grid system. His finding pointed out ongoing improvement through close collaboration with Kenya transmission Company (KENTRACO) and Energy regulation Commission (ERC).

2.3.3 Quality

According to (Kelemen 2006), Quality in a managerial term is defined as a self contained entity or process that can be planned, managed, controlled with the help of technical and managerial knowledge. According to American society for quality defines quality as the total features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs. Quality has a cost. Critical to power plants are internal failure; cost as a result of defective parts and services before delivery of services e.g. rework, scrap downtime and external cost that result after delivery of defective parts or services e.g. rework, returned goods, liabilities, lost goodwill cost to society (Heizer & Render, 2009). Generation of electricity is a system of inter related activities and processes that must meet certain conditions. First is the power factor and secondly voltage factor prior to an engine synchronizing with the grid. Failure to which, generating sets initiates shut down or a trip. Therefore quality electricity is a subject of procedures, fuel specification, quality spares, and quality operations. HSB (2008) reveals that over the life of engine, fuel represents over 75% of total operating cost. The organization also states that failure to maintain quality results to premature engine failure and decreased performance.

SKF (2008) stipulates that whether combusting fossil fuels or splitting atoms, all power generating facilities today face the same challenge i.e. how to optimize output in the face of rising fuel and maintenance costs, reduced manpower, and increasingly stringent environmental and safety regulations.

In TPP, running and maintenance of the gensets has many activities. To keep abreast of the same, procedures have been formulated to guide the engineers and technicians in execution of activities. Omission of these procedures does arise. This is attributable to number of reasons namely fatigue, sickness, attitude and speed etc. All these affect operations leading to production losses.

Spares quality are critical component in determining the efficiency of the Gensets. At the Research Development and Design (RD&D), Gensets are approved for the market. Original spares were used to test the design. With liberalization of world market, companies have introduced alternative spares that are less expensive. These spares display flaws in other attributes like temperature, fatigue etc. As such, they give in leading to breakdowns hence unplanned outage which is a cost element in generation. Tumer & Huff (2008) in his study in USA on effect of production and maintenance variation on machinery indicated that the intended function of a component can be compromised if there are variations introduced during the production and maintenance which result in undesired side effects. He went ahead and explained the combinations of tools like (six sigma, inspection, statistical control, Taguchi robust design method and error budgeting) used by designers to assess and eliminate variations with the goal of producing higher quality parts with less scrap or rework hence reducing the time and cost of product development. Tumer & Huff, (2008) of USA in his findings on rotating machinery functionality and performance can be hindered by excessive vibrations resulting from variations and defects in individual components. Also the study revealed that a prediction of potential deviation from the intended functional requirements will not only reduce safety but also avoid premature failure, but also shorten the product cycle by avoiding scrap work and inspection as well as decrease costs associated with unplanned maintenance. Two of the significant factors cause's undesired vibrations are manufacturing and assembly error.

Calorific value determines the energy inherent in the fuel. Fuel used must pass the quality tests since will determine maximum output from the Gensets. Omission on inspection compromises quality delivery. Poor oil specifications leads to under utilization of Gensets hence poor performance. Mining, storage, and transport of fuel counts on the impurities. Amount of silt present determines its quality. Storage sites are coupled with weather conditions occasionally rain water get into the tanks. Water in fuel causes filtration failure leading to high overheads in the treatment of the fuel and more parts replacement. Locally transportation of this fuel to the generation site is marred by unscrupulous business people. Some opt to sell fuel and replace with water. If this go unnoticed automatically lead to system failures leading to shut downs.

2.3.4 Cooling water

Cooling water for energy generation is accounted for differently in different countries. Due to the large amount of water required to cool energy generation plants, and in light of the predicted future increase in energy consumption for the coming years, Franken & Kohl (2011) established water withdrawals associated with power generation must be taken into consideration. Cooling in thermal power plant is critical to the safety of the equipments. In the generation process, heat is produced as a bye product and must be eliminated from the system. To do this cooling towers are used. Cooling towers are of two types namely open system and closed system. Open system involves losing of water to the drain after certain cycles and closed system circulates water in the cooling process. Both systems pose challenges to the operations.

While in the generation process, open systems release large volumes of water to the drain. Considering many discreet units and intermittent supply of water, a lot of water is used for steam generation. The challenge is compounded with the water rationing in the country and also saline water which has to go through treatment process. This poses a big challenge in terms of cost implication. Modern cooling system entailing a closed system has partly solved the open system loss. However, has introduced other challenges of auxiliaries that have left operation managers doubt if the technology is a blessing or a curse. Open system come with double blow. One is the maintenance of the reverse osmosis plant and two is the water that is rejected in the treatment cycle (Karaghouli & Kazmerski, 2008). Investment of reverse osmosis plant is as good as acquiring another genset. Maintenance cost of the units is very expensive in terms of spares and consumables replacement.

According to (Veolia, website) despite (RO) producing good quality water for generating steam for the power plant, 40% of the water is rejected by the system. The rejected water is released to the drain. TPP are therefore subjected to heavy investment in RO plant. Occasionally operations of the plant experiences decreased water levels. As a result the plant runs on reduced load to create more time to build more water. During this period, salaries are fully paid for and it’s a heavy burden to the performance of the company.

2.3.5 Spares Procurement

The technology use in the thermal power plant and the equipments themselves are virtually new. The same reflects on specialised services, equipment service i.e. and spares sourcing are offshore therefore creating need for effective supply chain management. The pressure to reduce inventory investments in supply chains has increased as competition expands and product variety grows hence companies are looking for areas they can improve to reduce inventories without hurting the level of service provided. Amongst the two areas that managers focus on are the reduction of the replenishment lead time from suppliers and the variability of this lead time (Chopra, Reinhardt & Dada, 2004). The same statement is echoed by (Mae & Ohno, 2012) whose study revealed global competition and market uncertainty resulting too many companies having international operations and thereby complex logistics networks. However, challenges resulting from globalization are longer supply lead times, unreliable transit times, various consolidation possibilities and a number of transportation mode as well as cost options (Bowersox, 2010). There are a number of reasons causing these challenges such as financial requirements, need for special packaging, ocean freight scheduling and customs clearance. As such supply chains become less consistent and flexible because of longer supply lead times. Accordingly, planning and coordination of the material flow becomes a demanding task. Due to the costs involved in the power plant, spares procurement have resulted to adoption cost efficient philosophies and reduced lead times posing a challenge as to whether the move is a gain or loss to the companies.

Coupled with the state of the clearance at the port of entry, the challenge is aggravated the more due to the delays. Due to these episodes generating systems have been subjected to losses on production hence affecting large industrial companies, businesses, and even home users of the precious commodity. Likewise repair of specialised equipments are available offshore due to unavailability of local expertise and facilities. Lead times are at the mercies of the service providers as the TPP continues to count losses. The same experience is shared when there arise need for insurance examination in case of heavy break down. TPP are left with no options other than biting the humble pie. Also some of these equipments are not stock items, they are made on order

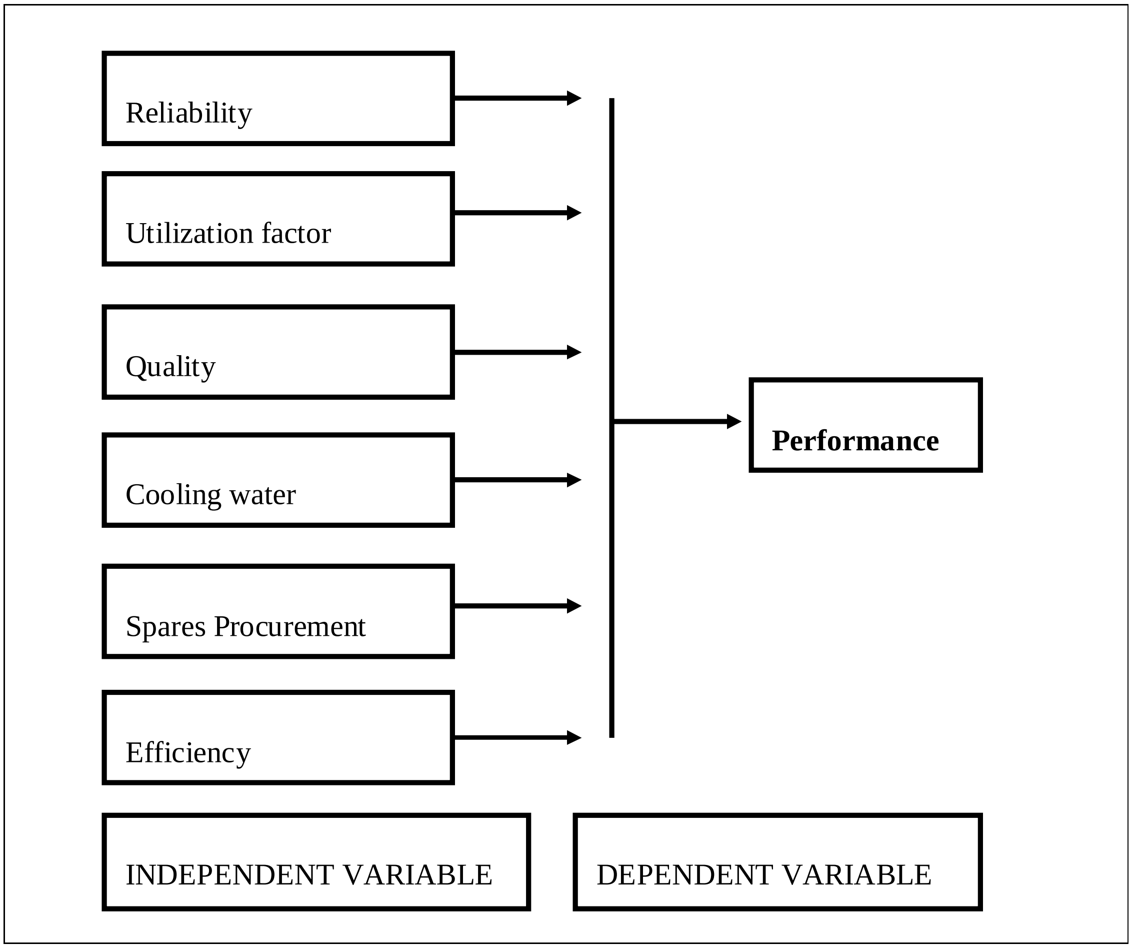
2.3.6 Efficiency

Peter (2010) in his study on renewable revealed efficiency as the 'fifth fuel' a new source of energy that can be tapped to drive economic growth. He also established that, if the world got serious with the efficiency it would reduce energy demand by half. In the context of TPP efficiency is determined by the amount of fuel oil, lube oil and water used in the generation of kilowatt hour (KW/h) electricity measured in grams. PPA is specific on amount of fuel used to generate a KW/h of electricity. It is therefore the responsibility of the TPP management to check their systems to be in business. Measure of fuel used per KW/h electricity is called Specific fuel Oil Consumption (SFOC) and lube oil specific lube oil consumption (SLOC). It measures how effectively an engine uses fuel supplied to produce work (Saber, Al-Barwari & Talabany, 2013). PPA stipulates a specific amount of fuel to generate a KW/hr of electricity. Need to use less fuel the better for the business, more fuel translates to losses. NO_x emissions are consequently critical in determining the fuel oil consumption of a Genset. Machine efficiency is determined by spares quality, fuel quality, engine design and facility location.

2.4 Chapter Summary

From the literature review, it is evident that thermal power plant is compounded by many challenges that can hinder the performance of the TPP. However, the challenges are common with all thermal power plants. Amongst the operational challenges are reliability, equipment utilization, Quality, water problem, Spares procurement and efficiency. The manufacturer of various engines models i.e. Wartsila, Niigata, Man, Caterpillar, Volvo engines have therefore resulted to engage in research and design and the process is ongoing. Despite quality studies by researchers and application of operation tools to mitigate the challenges, the optimal performance of the power plant is still threatened. Some of the success stories in other plants across the globe have been shared hence solutions are inevitable. Therefore this study seeks to establish the operational in challenges in thermal power plants

Figure 2.1 Conceptual framework



Source, Author (2013)

2.5 Research hypothesis

A hypothesis is a research statement that depicts the relationship between two or more variables. According to (Prasad, Rao & Rehani, 2001) hypothesis can also be described as a testable prediction about what is expected to happen in a study and can be derived from the conceptual framework. Therefore according to figure 2.1 above, “This study is thus designed to assess hypothesis that operational challenges affect the performance of thermal power plants in Kenya”.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter is a blueprint of the methodology that were used by the researcher to find answers to the research questions. It includes the research design, population of the study, data collection methods, and data analysis.

3.2 Research Design

This study adopted a descriptive research design. A descriptive study is concerned with determining the frequency with which something occurs or the relationship between variables (Bryman & Bell, 2003). Descriptive research design is a valid method for researching specific subjects and as a precursor to quantitative studies. In this case, the research problems were the operation challenges affecting thermal Power plant in Kenya. Thus, this approach was appropriate for this study as it helped to describe the state of affairs as they existed without manipulation of variables (Kothari, 2004).

3.3 Population and Sampling

The target population is the specific population about which information is desired (Kothari, 2004). According to Ngechu (2004), a population is defined as a set of people, services, elements, events, group to be investigated. This definition ensures that population of interest is homogeneous. The populations of interest in this study were all thermal Power plants in Kenya (See Appendix IV). Census approach was used owing to the small number of TPP in Kenya. The respondents in this study were two main departments namely Operations and maintenance that are concerned with the generation of electricity.

3.4 Data collection

Primary and secondary data were used in this study. Secondary data was important because it provided first hand information on the challenges discussed in the literature review. More information was gathered from the log books, dispatch report, management review meetings report, handover reports, work orders etc.

Primary data was be gathered using the questionnaire. The questionnaire was divided into two parts. Part one constituted of the respondent bio data, the second part the challenges and

Respondents were required to rate their responses using a 5 point likert scale designed questionnaire. This design enabled the researcher to capture the positive and negative attributes from the respondents. The questionnaires were administered through emails and drop and pick method. Telephone calls were also used for clarification on some questions and probing. In each department, the questionnaire was administered to the departmental manager, two engineers and three supervisors. For the two departments, a total of twelve respondents were target. For the six plants as listed in (appendix IV) a total of seventy two respondents were slotted for interview.

3.5 Data Analysis

Before processing the responses, the completed questionnaires ware edited for completeness and consistency. Quantitative data collected was analyzed by use of descriptive statistics to generate percentages, means, standard deviations and frequencies. This was done by tallying up responses, computing percentages of variations in response as well as describing and interpreting the data in line with the study objectives and assumptions. Tables and other graphical presentations as appropriate were be used to present the data collected for ease of understanding and analysis. Information generated was then be interpreted and explained.

Table 3.1 Summary of Research Design and Methodology

Objective	Data	Purpose	Analysis	Display
To determine the Operational challenges affecting performance of thermal power plants in Kenya	Primary/Secondary (Actual experiences)	Determine the operational challenges that affect performance of thermal power plants	SPSS	Summary table of the responses, Chi square.

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents analysis and findings of the study as set out in the research methodology. The study findings are presented on Operational challenges affecting performance of Thermal power plants in Kenya. The data was gathered exclusively from the questionnaire as the research instrument. The questionnaire was designed in line with the objectives of the study. Data analysis was done using percentages, mean and the chi square tests.

4.2 Response Rate

Questionnaires were distributed to the Technicians, Supervisors, Engineers and Managers of the six TPP as listed in appendix IV. This reasonable response rate was made a reality after the researcher made personal calls and visits to remind the respondent to fill-in and return the questionnaires. The table 4.1 below represents responses amongst the sampled companies.

Table 4.1 Companies sampled and actual response rates

Company	Response rate				
	Sampled Numbers		Actual Numbers		Percentage of the Sample
	Frequency	Percent	Frequency	Percent	Percent
Aggreko	12	16.67	9	15.30	75.00
Ibera Africa	12	16.67	13	22.00	108.33
KenGen	12	16.67	10	16.90	83.33
Rabai	12	16.67	9	15.30	75.00
Thika Power	12	16.67	9	15.30	75.00
Tsavo Power	12	16.67	9	15.30	75.00
Total	72	100.00	59	100.00	81.94

Source: Research data (2013)

From table 4.1 above, the response rate was 81.94%. This seen as a fair presentation of data gathered and could be used to make judgment on the research subject.

4.3 Bio Data analysis

Table 4.2 Gender distribution

	Sex				
	Male	**Female**	**Male %**	**Female %**	**Total %**
Aggreko	9	0	100.0	0	100.0
Ibera Africa	13	0	100.0	0	100.0
KenGen	10	0	100.0	0	100.0
Rabai	9	0	100.0	0	100.0
Thika Power	9	0	100.0	0	100.0
Tsavo Power	9	0	100.0	0	100.0
Total	59	0	100.0	0	100.0

Source: Research (2013)

From the statistics in table 4.2 above, it was established that all the employees in the thermal power plants are men. This suggests that, the nature of work could favour only men and not women.

Table 4.3 Age distribution amongst employees

Company	**Age Bracket**									
	20-29 years		**30-39 years**		**40-49 years**		**50-59 years**		**Total**	
	Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Aggreko	7	77.8	2	22.2	0	0.0	0	0.0	9	100.0
Ibera Africa	0	0.0	6	46.2	4	30.8	3	23.1	13	100.0
KenGen	1	10.0	3	30.0	5	50.0	1	10.0	10	100.0
Rabai	1	11.1	6	66.7	2	22.2	0	0.0	9	100.0
Thika Power	1	11.1	7	77.8	1	11.1	0	0.0	9	100.0
Tsavo Power	8	88.9	1	11.1	0	0.0	0	0.0	9	100.0
Total	18	30.5	25	42.4	12	20.3	4	6.8	59	100.0

Source: Research data 2013

From table 4.3 above, about 30.5 % of all employees in the Thermal Power plants companies were of the age between 20-29 years. A majority of the respondents were 42.4% between the ages 30-39 years. Only 6.8% were of the ages 50-59 years. Tsavo Power had the highest number of employees in the age bracket between 20-29 years at 88.9% followed by Aggreko with 78.7% .Thika Power has the highest number of employees in the age bracket 30-39 years followed by Rabai. KenGen had the highest number of employees above 40 years while Iberafrica had 23.1% of the employees in the bracket 50-59 years.

Table 4.4 Distribution of respondents by academic qualification

Company	What is your highest academic qualification?							
	Diploma		First Degree		Master Degree		Total	
	Count	%	Count	%	Count	%	Count	%
Aggreko Power	7	77.8	2	22.2	0	0.0	9	100.0
IberafricaPower	7	53.8	5	38.5	1	7.7	13	100.0
KenGen	5	50.0	4	40.0	1	10.0	10	100.0
Rabai Power	7	77.8	2	22.2	0	0.0	9	100.0
Thika Power	5	55.6	4	44.4	0	0.0	9	100.0
Tsavo Power	7	77.8	2	22.2	0	0.0	9	100.0
Total	38	64.4	19	32.2	2	3.4	59	100.0

Source: Research data (2013)

From table 4.4 above on the academic qualification, most of the respondents had diploma level of education at 64.4% followed by first degree 32.2%. Only 2 individuals that is 1 from KenGen and 1 from Iberafrica had master level education. Thika Power had the highest number of employees with First degree at 44.4%, followed by KenGen 40.0% and Iberafrica 38.5 %. These findings indicate that all respondents were highly educated and thus could easily respond to the questions posed informatively.

Table 4.5 Distribution of respondents by present position occupied

Company	Present position at your establishment							
	Technician		Supervisor		Engineer		Total	
	Count	%	Count	%	Count	%	Count	%
Aggreko	7	77.8	2	22.2	0	0.0	9	100.0
Ibera Africa	2	15.4	7	53.8	4	30.8	13	100.0
KenGen	2	20.0	4	40.0	4	40.0	10	100.0
Rabai	6	66.7	3	33.3	0	0.0	9	100.0
Thika Power	3	33.3	5	55.6	1	11.1	9	100.0
Tsavo Power	7	77.8	1	11.1	1	11.1	9	100.0
Total	27	45.8	22	37.3	10	16.9	59	100.0

Source: Research data (2013)

From table 4.5, about half of the respondents were technicians at 45.8%, and 37.3 % were supervisors while 16.9% were engineers. Thika Power had a large number of supervisors at 55.6% of its workforce while 77.8% of the staff at Aggreko and Tsavo power were technicians. Iberafrica and KenGen had above 30% of their workforce composed of engineers. This indicates that the questionnaires were responded to by qualified employees in their areas far as the study is concerned. Also the ratio of the positions of respondents was fair.

Table 4.6 Distribution of respondents by period work experience

Company Name	How long have you been with the company?											
	1-4 years		5-9 years		10-14 years		15-19 years		Over 20 years		Total	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Aggreko	0	0.0	9	100.0	0	0.0	0	0.0	0	0.0	9	100.0
Ibera Africa	2	15.4	5	38.5	3	23.1	3	23.1	0	0.0	13	100.0
KenGen	3	30.0	2	20.0	2	20.0	2	20.0	1	10.0	10	100.0
Rabai	7	77.8	1	11.1	1	11.1	0	0.0	0	0.0	9	100.0
Thika Power	1	11.1	4	44.4	4	44.4	0	0.0	0	0.0	9	100.0
Tsavo Power	1	11.1	8	88.9	0	0.0	0	0.0	0	0.0	9	100.0
Total	14	23.7	29	49.2	10	16.9	5	8.5	1	1.7	59	100.0

Source: Research data (2013)

From table 4.6 above and considering the period the respondents have been working in their respective stations, 49.2% the respondents have served their companies for between 5-9 years while about 23.7% have served in their their companies for about 1 to 4 years. All the Employees in Aggreko have been with the company for between 5 to 9 years. 8.5 % have served for between 15-19 years while only 1% which is 1 employee has served KenGen for over 20 years. From these statistics it is established that there is a very clear distribution on the positions and the succession plan is in force hence no vacuum in the experienced.

Table 4.7 Reliability of Operations in Thermal Power Plants

	Reliability Aspect	SD (%)	D (%)	NAD (%)	A (%)	SA (%)	Weighted Mean
1	Weak generation network can result to plant failures	0.00	3.39	11.86	59.32	25.42	4.0678
2	Most outages are externally induced	0.00	6.78	8.47	61.02	23.73	4.0169
3	Human errors constitute to Unavailability	1.69	10.17	15.25	66.10	6.78	3.6610
4	Power outages are often experienced	3.39	15.25	8.47	62.71	10.17	3.6102
5	Failure of Crankshaft, Engine block and transformer can take more than three months to fix	13.56	10.17	16.95	32.20	27.12	3.4915
6	Outages lead to secondary failure of equipment	8.47	11.86	37.29	30.51	11.86	3.2542
7	Increased demand affect plant availability	11.86	22.03	22.03	28.81	15.25	3.1356
8	The Company has generation reserve (reserve engine)	55.93	15.25	0.00	3.39	25.42	2.2712
9	Most outages are internally induced	27.12	44.07	16.95	11.86	0.00	2.1356
	Total	13.56	15.44	15.25	39.55	16.20	3.29

Source: Research data (2013)

Key: SD-Strongly Disagree, D- Disagree, NAD-Neither Agree or Disagree , A-Agree, SA-Strongly Agree

From table 4.7 above, majority of the respondents agree and strongly agree that weak generation network results to plant failures. This is evident by 59.32% & 25.42 % depicted by the respondents. Weak generation network (grid system) at 61.2% agrees & 23.73% agree is the main cause of reliability challenge. On human errors concern, 66.1% agree is also a cause of poor reliability. All respondents also agree that power outages are often experienced in the thermal power stations by all companies at 62.71%. Failure of Crankshaft, Engine Block and transformer can take more than three months to fix that is according to 32.20% who agreed to that extent and 27.12% who strongly agreed respectively. The weighted mean when measuring this aspect shows that most of the respondents are in agreement of the time delays in fixing these failures. Outages are also believed to be the cause of secondary failure the power stations. 30.51 % agree to this fact. A large number of the respondents 37.29 % could neither agree nor disagree that outages lead to secondary failure of equipment while 30.51% agreed that outages lead to secondary failure of equipment.

Human errors were seen to contribute to unavailability of power plants reliability as evidenced by about 6 in 10 of the respondents agreeing and about one quarter strongly agreeing. In another instance, 55.93 % of the respondents were of the view that their companies did not have generation reserve (reserve engine). About 6 in 10 of the respondents agree that most outages are externally induced and 44.07% disagree that most outages are internally induced. From the statistics above operational challenges critically affect performance of thermal power plants. Fundamental to this fact are external concerns followed by internal. Hence, reliability is a key performance indicator of performance of thermal stations.

Table 4.8 Utilization factor of thermal power plants

	UTILIZATION ASPECT	SD (%)	D (%)	NAD(%)	A (%)	SA (%)	Total (%)	Weighted Mean
1	Hydro power plant performance reduces thermal power plant utilization factor	0.00	6.78	13.56	40.68	38.98	100.00	4.1186
2	What is the extent of the utilization factor for the Gensets	0.00	8.47	47.46	32.20	11.86	100.00	3.4746
3	Dispatch is the main cause of low utilization	3.39	32.20	15.25	32.20	16.95	100.00	3.2712
4	Occasionally, utilization factor reduces to below half	10.17	25.42	15.25	35.59	13.56	100.00	3.1695
5	Human errors lead to long stoppages hence low plant utilization	6.78	30.51	28.81	20.34	13.56	100.00	3.0339
	Total	4.07	20.68	24.07	32.20	18.98	100.00	3.4136

Key :

SD-Strongly Disagree, D- Disagree, NAD-Neither Agree or Disagree, A-Agree, SA-Strongly Agree

The Gensets were underutilized based on the responses of those sampled with 32.20% of them agreeing that performance of hydro power plant reduces utilization of the thermals. 18.98% also agreed to this fact. While considering the extent of utilization factor, 32.2% at a weighted mean of 3.47 agreed that utilization factor of total installation is about 55 %. A big percentage disagreed with the idea that human errors leads to long stoppages hence reducing utilization. However, there were small fragments of respondents who conquered to this fact as evidenced by 20.34% who agreed and 13.56% strongly agreed.

About 32.20% of the respondents agreed that dispatch was the main cause of low utilization while 16.95 % strongly disagreed. However, this there was diverted view on this regard as the same percentage of 32.20 % on the fact that dispatch was the main cause of low utilization. On the other hand, 16.95 % strongly agreed to this fact. As a result, the general response when it came to the fact that occasionally, utilization factor reduces below half were that, 35.59% were in agreement while 13.56% were in strong agreement. It was also evident that Hydro power plant performance reduces thermal power plant utilization since 38.98% strongly agreed with this observation while 40.68% agreed to an extent.

From these statistics it can asserted that, poor utilization factor is as a result of many factors as discussed and it’s the reason why performance of the thermal stations is challenged by the operationally concerns.

Table 4.9 Quality Considerations in thermal power plants

	QUALITY ASPECT	SD (%)	D (%)	NAD (%)	A (%)	SA (%)	Total (%)	Weighted Mean
1	Company has quality strategy in place	0.00	0.00	1.69	33.90	64.41	100.00	4.6271
2	Spares constitute to quality concerns in operations	0.00	0.00	5.08	42.37	52.54	100.00	4.4746
3	Company uses quality tools to ensure smooth operations in all areas of power generation	0.00	0.00	3.39	52.54	44.07	100.00	4.4068
4	Company uses original and genuine spares for maintenance	0.00	0.00	10.17	40.68	49.15	100.00	4.3898
5	What is the level of fuel oil quality	0.00	1.69	5.08	57.63	35.59	100.00	4.2712
6	What is the level of lube oil quality	0.00	0.00	11.86	55.93	32.20	100.00	4.2034
7	Work procedure are adhered to always	0.00	5.08	13.56	40.68	40.68	100.00	4.1695
8	Alternative spares is a critical component of quality failure	0.00	3.39	15.25	42.37	38.98	100.00	4.1695
9	Work procedures are critical to the lowest level of plant personnel	6.78	3.39	16.95	30.51	42.37	100.00	3.9831
10	Truck transporters interfere the quality of fuel	10.17	23.73	33.90	20.34	11.86	100.00	3.0000
	Total	1.88	4.14	12.62	40.49	40.87	100.00	4.1431

Source: Research data (2013)

On quality aspects, most of the stations have a quality strategy in place as evidenced by the positive acceptance responses where about 33.90% agreed to this statement and 64.41%

strongly agreed to it. The level of fuel oil quality and lube oil quality also affect the overall quality of the operations as shown by the responses in table 4.8.

A majority of the companies use original and genuine parts for maintenance, with most of the respondents agreeing at 40.68% and 49.15% strongly agreeing that genuine parts were being used for maintenance of their engines.

About 52.54% of the respondents strongly agreed that spares constitute to quality concerns in operations, the weighted mean on this aspects was so high amongst the respondents (4.4746) which translates to strong agreement to this aspect on quality.

The respondents felt that truck transporters do not or some do interfere with the quality of the fuel and a weighted mean of 3.0 shows that they neither agree to this fact.

Above all the quality aspects 40.89% agreed with them while 40.87% had a strong agreement with them. Therefore quality as a key performance indicator is seen as a critical element in thermal generation and is an area that is perfected by the stations hence not posing any challenges to the thermal stations.

Table 4. 10 Cooling Water Considerations in Thermal Plant Operations

COOLING WATER ASPECT		**SD (%)**	**D (%)**	**NAD (%)**	**A (%)**	**SA (%)**	**Total (%)**	**Weighted Mean**
1	Plant operations use treated water always	0.00	1.69	1.69	25.42	71.19	100.00	4.6610
2	RO plant runs continuously	0.00	8.47	25.42	30.51	35.59	100.00	3.9322
3	Maintenance of (RO) plant is frequent	6.78	10.17	32.20	38.98	11.86	100.00	3.3898
5	Running RO System is costly	11.86	8.47	38.98	22.03	18.64	100.00	3.2712
4	Occasionally plant reduces load due to water shortage	28.81	25.42	35.59	8.47	1.69	100.00	2.2881
Total		9.49	10.85	26.78	25.08	27.80	100.00	3.5085

Source: Research data (2013)

On cooling water aspects, power plants were seen to use treated water always and its availability was paramount for smooth operations, 71.19% of the respondents strongly agreed to this fact. The weighted mean on this aspect scored 4.6610 which showed a strong element of agreement on the use of treated water.

The RO plant runs continuously to some extent as reported by the respondents. Most of the respondents showed a negation when it came to the fact that occasionally plant reduced load due to water shortage. This is an indication that plants were running optimally indicating its availability.

The maintenance of the RO plant was observed to be frequent as described by the respondents in table 4.10 agreeing on this aspect at 38.98 % and 11.86 % Strongly Agreeing on the same.

The respondents to a greater extent neither agreed nor disagreed over the fact that running the RO system is costly. The explanation to this fact is that, thermal generation highly depends on treated water. This is seen by the stations willingness to part with maintenance costs and possible installation oh high capacity RO systems to ensure available of treated water.

Table 4.11 Spares Procurement Considerations in Thermal Power Plant Operations

SPARES PROCUREMENT ASPECT		SD (%)	D (%)	NAD (%)	A (%)	SA (%)	Total (%)	Weighted Mean
1	Spares are critical to plant performance	1.69	1.69	0.00	18.64	77.97	100.00	4.6949
2	Some equipments, spares are manufactured on order	1.69	11.86	8.47	50.85	27.12	100.00	3.8983
3	The company uses JIT to reduce inventory	8.47	11.86	33.90	30.51	15.25	100.00	3.3220
4	Occasionally the plant results to alternative spares	3.39	28.81	25.42	25.42	16.95	100.00	3.2373
5	Financial constraints results to alternative spares	28.81	28.81	22.03	10.17	10.17	100.00	2.4407
Total		8.81	16.61	17.97	27.12	29.49	100.00	3.5186

Source: Research data (2013)

From table 4.11 above, responses on the aspect of spares procurement was seen to be critical to plant performance. The summed response indicates that a majority of the respondents strongly agreed (weighted mean 4.6949) that spares are critical to plant performance. There is varied use of alternative spares occasionally as evidenced by the varied responses on the aspect of alternative spares. It was evident that spares are manufactured on order as indicated by 50.85 % agreeing to this fact. These findings here are pegged on the specialized spares which are not available locally. Need to maintain high level of strategic alliance with the suppliers is paramount.

Table 4.12 Efficiency Considerations in Thermal Power Plant Operations

EFFICIENCY ASPECT		SD (%)	D (%)	NAD (%)	A (%)	SA (%)	Total (%)	Weighted Mean
1	Spares quality contribute to engines efficiency	0.00	0.00	0.00	38.98	61.02	100.00	4.6102
2	Spares quality contribute to engines performance	0.00	1.69	0.00	44.07	54.24	100.00	4.5085
3	Engines are efficient in terms of fuel oil consumption	0.00	5.08	0.00	54.24	40.68	100.00	4.3051
4	Engines are efficient in terms of lube oil consumption	0.00	1.69	8.47	61.02	28.81	100.00	4.1695
5	Water is a factor of plant performance	1.69	6.78	8.47	44.07	38.98	100.00	4.1186
Total		0.34	3.05	3.39	48.47	44.75	100.00	4.3424

Source: Research data (2013)

In all the TPP, responses are such that, engines are efficient in terms of fuel oil consumption. 54.24% of the respondents agreed to this fact while 40.68% strongly agreed on it. Moreover 61.02% of the respondents agreed that engines are efficient in terms of lube oil consumption while 28.81% strongly agreed that engines are efficient in terms of lube oil consumption. A very large number of the respondents strongly agreed that (61.02%) of spares quality contribute to engines efficiency. On the same aspect of spare 54.24% of the respondents strongly agreed that spares quality contributed to engines performance. Water is a factor of plant performance as agreed upon by 44.07% of the respondents.

4.4 Statistical Analysis of Operational Challenges and their contribution to Performance.

4.3.1 Reliability VS Performance.

Table 4.13 Reliability measure towards performance

		Reliability			Total
		Neither Agree nor Disagree	Agree	Strongly agree	
Performance	Neither Agree nor Disagree	25.4%	0.0%	0.0%	25.4%
	Agree	44.1%	28.8%	0.0%	72.9%
	Strongly agree	0.0%	1.7%	0.0%	1.7%
Total		69.5%	30.5%	0.0%	100.0%

Source: Research data (2013)

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.244	4	0.024
Likelihood Ratio	15.796	4	0.003
Linear-by-Linear Association	10.638	1	0.001
N of Valid Cases	59		

Expalantion

Performance of Thermal power plants is directly contributed to by the reliability of their operations. A measure of significance between reliability and performance indicates significance levels at (0.024 < 0.1) which is a high positive association

Source: Research data (2013)

4.3.2 Utilization factor VS Performance

Table 4.14 Utilization measure towards performance

		Utilization Factor			Total
		Disagree	Neither Agree nor Disagree	Agree	
Performance	Neither Agree nor Disagree	5.1%	18.6%	1.7%	25.4%
	Agree	3.4%	25.4%	44.1%	72.9%
	Strongly agree	0.0%	0.0%	1.7%	1.7%
Total		8.5%	44.1%	47.5%	100.0%

Source: Research data (2013)

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.731	4	0.005
Likelihood Ratio	17.106	4	0.002
Linear-by-Linear Association	13.616	1	0.000
No of Valid Cases	59		
Explanation The utilization factor is a strong contributor of performance, significant at (0.005<0.1) indicating strong positive association.			

Source: Research data (2013)

4.3.3. Quality Vs Performance

Table 4.15 Quality measure towards Performance

		Quality			Total
		Neither Agree nor Disagree	Agree	Strongly agree	
Performance	Neither Agree nor Disagree	1.7%	20.3%	3.4%	25.4%
	Agree	0.0%	55.9%	16.9%	72.9%
	Strongly agree	0.0%	0.0%	1.7%	1.7%
Total		1.7%	76.3%	22.0%	100.0%

Source: Research data (2013)

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.028	4	0.134
Likelihood Ratio	6.388	4	0.172
Linear-by-Linear Association	3.209	1	0.073
No of Valid Cases	59		
Explanation Quality contributes towards performance but performance is not directly pegged on quality as indicated by the significance test (0.134 > 0.1) thus not significant.			

Source: Research data (2013)

4.3.4 Cooling Water Vs Performance.

Table 4.16 Cooling Water measure towards Performance

		Cooling Water				Total
		Disagree	Neither Agree nor Disagree	Agree	Strongly agree	
Performance	Disagree	0.0%	0.0%	0.0%	0.0%	0.0%
	Neither Agree nor Disagree	0.0%	20.3%	5.1%	0.0%	25.4%
	Agree	1.7%	44.1%	23.7%	3.4%	72.9%
	Strongly agree	0.0%	0.0%	1.7%	0.0%	1.7%
Total		1.7%	64.4%	30.5%	3.4%	100.0 %

Source: Research data (2013)

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.615[a]	6	0.594
Likelihood Ratio	5.479	6	0.484
Linear-by-Linear Association	2.085	1	0.149
No of Valid Cases	59		

Explanation

Water is not directly associated with the performance of thermal power plants although there exists some positive relationship, not significant at (0.594 > 0.1) thus not directly related.

Source: Research data (2013)

4.3.5. Spares Procurement Vs Performance.

Table 4.17 Spare Procurement measure towards Performance

		Spares Procurement				Total
		Disagree	Neither Agree nor Disagree	Agree	Strongly agree	
Performance	Disagree	0.0%	0.0%	0.0%	0.0%	0.0%
	Neither Agree nor Disagree	0.0%	16.9%	8.5%	0.0%	25.4%
	Agree	1.7%	23.7%	40.7%	6.8%	72.9%
	Strongly agree	0.0%	0.0%	0.0%	1.7%	1.7%
Total		1.7%	40.7%	49.2%	8.5%	100.0%

Source: Research data (2013)

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.801	6	0.010
Likelihood Ratio	12.177	6	0.058
Linear-by-Linear Association	6.489	1	0.011
No of Valid Cases	59		
Explanation Spares Procurement has a direct bearing on the performance of thermal power plants significant at (0.01 < 0.1) thus very significant. Indicating that the spares purchased have a direct bearing on performance			

Source: Research data (2013)

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4.3.6 Efficiency Vs Performance

Table 4.18 Efficiency measure towards Performance

		Efficiency			Total
		Neither Agree nor Disagree	Agree	Strongly agree	
Performance	Neither Agree nor Disagree	1.7%	23.7%	0.0%	25.4%
	Agree	1.7%	35.6%	35.6%	72.9%
	Strongly agree	0.0%	0.0%	1.7%	1.7%
Total		3.4%	59.3%	37.3%	100.0%

Source: Research data (2013)

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.154	4	0.011
Likelihood Ratio	18.425	4	0.001
Linear-by-Linear Association	12.089	1	0.001
No of Valid Cases	59		

Explanation.

Efficiency is directly related to performance as noted in the tables above significant at 0.011 < 0.1. Very strong relationship

Source: Research data (2013)

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the research findings presented in chapter four above. The conclusion drawn from the findings of the study are also presented in this chapter. The chapter also presents summary of the findings, conclusions and recommendations areas for further study.

5.2 Summary of Findings

The main objective of this research was to establish the operational challenges that affect performance of thermal power plants in Kenya. The findings of the study established that reliability, utilization factor, spares procurement and efficiency were seen to have a very strong bearing on the performance of the thermal stations. These external factors consisted of reliability and utilization aspects while internal factors consisted of spares procurement, cooling water, efficiency and quality. Cooling water and quality were seen not to have a strong bearing on the performance of these thermal stations.

According to the bio data analysis, it was revealed that, gender distribution was 100% male with ages between 30-49 years at 42.4% followed 20-29 years at 30.5% and 40-49 years at 20.35%. Iberafrica power showed presence of three employees at age bracket between 50-59 years. From this analysis, it is evident that the distribution of ages in the thermal power plants is fundamental in plant operations as it reflects the high energy age groups which fresh men from the universities and tertiary colleges. Also a good number at 42.45 % indicated mature employees at the peak of their careers.

Academic qualifications also come out as a factor that promotes performance. Amongst the levels are technical diploma, degree and master qualification. Diploma holders accounted to a majority 64.4%, degree 32.2 % and master 3.45 %. The ratio of distribution clearly fits the activities in the thermal generation in the two departments which are operations and maintenance. Qualifications are synonymous to positions held as seen in table 4.4. More diploma qualifications are expected than degrees and master qualification respectively. This aspect is synonymous to positions held as seen in table 4.5. These qualifications and practice are the reasons for high elements of quality, efficiency that have been established as strong elements in the study.

On positions held there are much more technicians than supervisors and engineers respectively. This is shown by a response of 45.8 % 37.3% and 16.9 % respectively. Technicians are expected on the shop floor much more than supervisors while engineers are expected to be less. Presence of master qualification is an indicator of future managers who shall be able to link engineering and management skills hence ability to make informed decision in thermal generation.

Most employees were also established to have served their companies for over five years followed by a good percentage who have served for more than ten years. This trend is synonymous to the advent of thermal power stations seventeen years ago.

Considering Reliability against performance, findings of the study established that **r**eliability was a critical aspect in generation. Statistical Performance of Thermal power plants is directly contributed to by the reliability of their operations. A measure of significance between reliability and performance indicates significance levels of $(0.024 < 0.1)$ which is a high positive association. The explanation is that outages induced externally have resulted to major challenges in the sector. Power outages were established as common challenges affecting performance. In turn outages result to secondary failure of expensive equipments whose lead time for repair is high resulting to heavy down times. This is a very expensive affair since it reduces the reliability which is a critical indicator in the power purchase agreement. Analysis also revealed that, companies seldom have generation reserve (reserve engine). Only two companies of the six have generation reserve while others did not.

On the Utilization factor, the study established that employees were uncertain with the utilization of the gensets despite deficiency of electricity in the country as established in the literature review. Human error and dispatch combined was also seen as another factor of low utilization. However, utilization factor has never gone below half but has not been fully exploited as declared to the KPLC.

Quality concerns i.e. TQM as established in the literature review was confirmed. This is evidenced by presence of quality strategies i.e. genuine spares and quality fuel. On quality aspects, most of the stations had quality strategy evidenced by 64.41% strongly agreed to it. The level of fuel oil quality and lube oil quality were established as strong practice.

Due to great heat generated during the production process of electricity, quality of cooling water was seen as not an option but a requirement. This was seen as a condition contained in the design phase. Continued performance is pegged on its availability. This is made possible by provision of reverse osmosis (RO) plant. As a result, rarely was load reduced due to unavailability of water. Some stations opted to incur high costs to have the system maintained while others opted to have high capacity system to ensure availability of water for smooth running of the operations.

Study also established that spares procurement served as a strong contributor of power plants performance. Maximum attention exercised on this aspect indicated negligible use of alternative spares a factor whichwas seen as critical in the operational process.

Efficiency in terms of engines consumption of oil and fuel was established. Gensets were established to be efficient in burning fuel to generate electricity. Lube oil consumption per kilowatt hour also come out as a strong aspects of performance.

5.3 Conclusions

The study established eminent challenges facing the performance of thermal power plants in Kenya. While considering the challenges visa vie performance, the study concludes that thermal power plant challenges are mostly due to external effects and particularly with KPLC who are buyers of bulk electricity and have exposed the power stations to performance risks. This critically touches on the reliability and utilization concerns.

It was also concluded that utilization of the thermal power stations is very low despite a high demand of electricity in the country. The declared out put to KPLC is not utilized optimally. This is not a good investment for the shareholders. On the same regard, poor workmanship constitutes to poor utilization factor. This is an internal factor within the generation system.

The study also concludes that issues that are internal to the generation stations have been significantly contained and are not big challenges to the performance of the thermal stations. This is evidenced by the high performance on quality concerns, spares procurement and efficiency respectively as practiced in the thermal power stations.

5.4 Recommendations

Due to the external challenges in the thermal power stations as a result of underdeveloped and centralized grid network, it is therefore recommended to upgrade the system by eliminating the long time monopoly as enjoyed by the KPLC so as to allow positive competition in the sector. The sector should embark on distributed generation system that will technically connect the whole country in line with vision 2030 while addressing challenges due to centralized grid system.

5.5 Limitations and suggestions for further research

The study was limited to thermal power plant only. It would have been prudent to incorporate KPLC who are owners of the national grid and are buyers of bulk electricity from all generation stations. Time was also limited to administer the questionnaire face to face so as to allow probing for more data to facilitate informed decision making.

The study suggests further research to address how the national grid can be developed to mitigate the grid related challenges that affect reliability and utilization factor. Further research can be done on best proven methods of formulating the PPA which currently is dependent of the performance of hydro stations. Also KPLC being a parastatal, the research would further require to establish why the document is not put on the public domain. Some companies have generation reserve and others don't. This is an area that also requires further research on how this affects performance in the generation sector.

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APPENDICES

APPENDIX I. Introduction Letter

University of Nairobi,
PO BOX 30197-00100,
13-8-2013.
Nairobi.
Dear sir/Madam,

RE: LETTER OF INTRODUCION (D61/64064/2010)

I am a master of business administration student at the University of Nairobi and in my final year of study. As part of the requirements for the award of the degree of Master of Business Administration, I am undertaking a research on "**Operational challenges affecting Power Plants in Kenya"**.

In this regard, I am kindly requesting for your support in terms of time, and by responding to the attached questionnaire. Your accuracy and candid response will be critical in ensuring objective research.

This is an academic research and confidentiality is emphasized, your name may not appear anywhere in the report. All the information that you provide will be treated with the strictest confidence and will not be used away from this study. Kindly spare to complete the questionnaire attached.

Thank you in advance for your co-operation.

Yours Sincerely,

Moses Kuria

APPENDIX II. Interview Guide

OPERATIONAL CHALLENGES FACING PERFORMANCE OF THERMAL POWER PLANTS IN KENYA.

Section A: Bio Data

1. Gender Male ( ), Female( )

2. State your Age Bracket

   20-29 years ( )
   30-39 years ( )
   40-49 years ( )
   50-59 years ( )
   Over 60 years ( )

3. What is your highest academic qualification?

   Diploma ( )
   First Degree ( )
   Master Degree ( )
   Doctoral Degree ( )
   Other Professional ( )

4. Present position at your establishment.

   Technician ( )
   Supervisor ( )
   Engineer ( )
   Manager ( )
   CEO ( )

5. How long have you been with the company?

   1-4 years ( )
   5-9 years ( )
   10-14 years ( )
   15-19 years ( )
   Over 20years ( )

SECTION B. Questionnaire

This questionnaire is intended to collect data on some of the best practices your power plant employs in the generation process. Your contribution is highly appreciated. All information gathered will be treated with utmost confidentiality.

Please indicate by ticking in the boxes provided in the following manner.

5 Means strongly agree
4 Agree
3 Neither Agree nor Disagree
2 Disagree
1 Strongly Disagree

Reliability						
Question No	Description	5	4	3	2	1
1	Power outages are often experienced					
2	Does the company have generation reserve					
3	Most outages are externally induced					
4	Most outages are internally induced					
5	Increased demand affect plant availability					
6	Outages lead to secondary failure of equipment failures					
7	Failures of Crankshaft, Engine block and transformer can take more than three months to fix					
8	Human errors constitute to Unavailability					
9	Weak generation network can result to failures					

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UTILISATION FACTOR						
Question No	Description	5	4	3	2	1
1	What is the extent of the utilisation factor for the gensets					
2	Human errors lead long stoppages leading to low utilisation					
3	Dispatch is the main cause of low utilisation					
4	Occasionally, utilisation factor reduces to half					
5	Hydro power plant performance reduces utilisation factor					

QUALITY						
Question No	Description	5	4	3	2	1
1	Company has quality strategy in place					
2	What is the level of fuel oil quality					
3	What is the level of lube oil quality					
4	Company uses original and genuine spares for maintenance					
5	Spares constitute to quality concerns in operations					
6	Work procedure are adhered to always					
7	Alternative Spares is a critical component of quality failure					
8	Truck transporters interfere the quality of fuel					
9	Work procedures are critical to the lowest level of operations					
9	Company uses quality tools to ensure smooth operations in all areas of power generation					

COOLING WATER						
Question No	Description	5	4	3	2	1
1	Plant operations use treated water always					
2	RO plant runs continuously					
3	How often does the plant reduce load due to water shortage					
4	Maintenance of RO plant is frequent					
5	Running RO system is costly					

SPARES PROCUREMENT						
Question No	Description	5	4	3	2	1
1	Spares are critical to plant performance					
2	Occasionally the plant results to alternative spares					
3	The company uses JIT to reduce inventory					
4	Financial constraints results to alternative spares					
5	Some equipments, spares are manufactured on order					

EFFICIENCY						
Question No	Description	5	4	3	2	1
1	Engines are efficient in terms of fuel oil consumption					
2	Engines are efficient in terms of lube oil consumption					
3	Spares contribute to engines efficiency					
4	Spares quality contribute to engines performance					
5	Water is a factor of plant performance					

APPENDIX III. CG and DG cost Value and Recommendation

Value	Distributed Generation	Centralised Generation	Recommendation
Continuous Power	Operated to allow a facility to generate some or all of its power to a relatively continuous basis. Important DG characteristics for continuous power include high electric efficiency & low emissions.	Though operated to provide continuous power, its characteristics results in. low electric efficiency as a result of high loses at the transmission system. High transmissions	For continuous power production, more DG need to be penetrated in CG based networks to reduce emissions and increase efficiency
Premium Power	It provides electricity service at higher level of reliability and power quality than typically available from the grid.	Provision of power at low reliability at power quality cannot be guaranteed due to inherent high power losses	Providing premium power would also need DG penetration in the CG network leading to better reliability and losses.
Cost	Low variable & maintenance costs	High variable & maintenance cost	DG is a preferred choice
Peaking	Operated between 50-3000 hours per year to reduce overall electricity cost	It is operated un-intermittently at various peak powers.	Combined CD and DG
Resilience	More resilient since it serves low power demands continuously	Less resilient but serves high power demands continuously	Combined CD and DG
Sustainability	Sources of power makes it more sustainable	Sources of power results in less sustainability	Combined CD and DG

Adapted from the white Paper (2012)

Cost Component	Centralised Generation	Distributed Generation	Recommendation
Cost of capital	Low cost per unit	High cost per unit	This approach would lead to reduced cost of the power grid system with the combined cg and dg
Fixed operation and maintenance cost	Higher	Lower	This approach would lead to reduced cost of the power grid system with the combined CG & DG
Variable maintenance and operation cost	Lower	Higher	DG is the preferred choice
Fuel	Same as DG	Same as CG	Combined DG and CG
Transmission	High voltage transmission is mandatory. high losses and transmission failure	Only distribution required. reduced capital cost	This approach would lead to reduced cost of the power grid system with the combined cg and dg
Expense for un-served energy	High	Lower	DG is the preferred choice

Adapted from the white Paper (2012)

APPENDIX IV. List of Thermal Power Plants

1	Iberafrica Power (EA) Limited
2	Rabai Power Plant
3	Tsavo Power Plant
4	Kipevu Power Plant
5	Agrreko Power Plant
6	Thika Power Plant

Source. ERC website (2013)