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MSc Programme in Urban Management and Development

Rotterdam, The Netherlands

September 2015

Thesis

Title: The influence of human resource and electricity tariffs on operation and maintenance and its effect on the quality of electricity supply in Zambia: A case of Zesco Lusaka division.

Name: Ernest Zulu

Supervisor: Dr. Ogenis Brilhante

Specialization: Managing & Financing Urban Infrastructure

MASTER'S PROGRAMME IN URBAN MANAGEMENT AND DEVELOPMENT

(October 2014 – September 2015)

The influence of Human Resource and electricity Tariffs on Operation and Maintenance and its effect on the quality of electricity supply in Zambia: A case of ZESCO Lusaka division.

Name: Ernest Zulu

Country: Zambia

Supervisor: Dr. Ogenis Brilhante

UMD 11 Report number: 859

Rotterdam, September 2015

Summary

Electricity utilities in Sub-Saharan Africa have been confronted with challenges of meeting electricity needs of their increasing populations and growing economies thereby putting pressure on their generation capacity and existing infrastructure. ZESCO is Zambia's single provider of electricity which is vertically integrated at generation, transmission and distribution. Following structural adjustment reforms in the early 1990s, ZESCO was commercialized as one of the conditions for the country to attain debt relief from donors. Since its commercialization, the utility has had to contend with inadequacies in its generation capacity due to a sharp rise in demand triggered by resurgent energy intensive copper mining and a growing population. On the other hand ZESCOs transmission and distribution infrastructure has over the years suffered deterioration due to underinvestment owing to low tariffs. Furthermore, inadequate operations and maintenance due to human resource management challenges and below cost tariffs has adversely affected the performance of the utility with regards to the quality of electricity supplied to consumers.

The aim of this study was to explain the influence that human resource and low tariffs have had on ZESCOs operations and maintenance activities and how this has affected the quality of electricity supplied to consumers in Lusaka city. The quality of electricity supply has in part been affected by inadequate generation capacity which the utility has been trying to address by commissioning new power generation rehabilitation and expansion projects in an effort to meet increasing demand. However, most of these projects are long term and will take time to come on board. In the meantime the utility's distribution and supply network remains constrained and unreliable as it suffers from overloaded lines and transformers resulting in frequent power outages. This research is therefore important as it informs decision makers on key elements of asset management and how this influences quality standards in the supply of electricity. Behavioural and management theories of organizations including the concept of strategic management were used to provide a comprehensive conceptual understanding of how ZESCO operates and provided the framework for analysis.

This study used a case study strategy, using interviews as the main data collection method. Qualitative data was collected from within the service provider and also from external respondents as a method of triangulating results. The main limitation was the time available for this research as interviews tend to be time consuming and therefore require sufficient time. However, this did not materially affect the results obtained. Further, secondary data was collected and used to corroborate the findings to increase validity. Data collected was analysed using a clustering approach aided by Atlas Ti and presented in tabular and graphical format. According to the main findings of the research; inadequate numbers of operations and maintenance staff; absence of an effective performance management system to motivate deserving employees; attitude of operations and maintenance staff towards work and; below cost tariffs which marginally cover operations and maintenance costs were found to be negatively affecting the service provider's operations and maintenance activities. Furthermore, information systems and tools had not been fully integrated to aid operations and maintenance activities thereby affecting performance. Based on these findings, the utility was not meeting its reliability targets set by the regulator.

In conclusion it was found that the human resource was to a large extent influencing ZESCOs performance in terms of its operations and maintenance activities. On the other hand, below cost tariffs were preventing ZESCO from making full cost recovery resulting in inadequate financial resources which to a great extent were compromising operations and maintenance activities. This had led to a deterioration in the quality of electricity supply in terms of its reliability. The study therefore recommends that the utility addresses human resource and operational matters identified in this research. In addition, ZESCO should strive to ensure that it attains cost reflective tariffs by lobbying the Energy Regulation Board to consider automatic

tariff adjustments based on economic metrics such as inflation, exchange rates and fuel costs. Finally, subsisting bulk supply agreements with mining companies which consume 60% of the load should be reviewed and renegotiated to improve ZESCOs revenue.

Keywords:

Human resource, electricity tariffs, operations and maintenance, quality of electricity supply.

Acknowledgements

First and foremost, I would like to give thanks to the Lord God almighty for blessing me with this opportunity to study for my master's degree through the Dutch government.

I wish to dedicate this work to my wife, Jene for being so supportive and understanding during my time away from home and kids Ayanda, Kutemwa and Nthokozo for always putting a smile on my face. I love you so much.

To my parents Aaron and Lillian Zulu for always encouraging and guiding me through my journey in life, I say words are not enough to express my gratitude to the both of you.

Special thanks also goes to my supervisor and course coordinator, Dr. Ogenis Brilhante for the knowledge and support provided throughout the specialization and research period.

Finally, I would like to thank all IHS staff and especially the course bureau for providing support through my stay in the Netherlands.

Colossians 3:17

Foreword

Operations and maintenance can significantly extend the life of an infrastructure asset. However there are several factors that influence operations and maintenance including both structural and non-structural assets. Human and financial assets are both critical to managing infrastructure assets to be able to deliver a service according to the desired level. Reliability indices are key performance measures adopted by regulators to measure the quality of electricity supply to be met by utilities based on best practice standards. This thesis explains the extent to which human resource and electricity tariffs influence operations and maintenance activities and how this affects the quality of electricity supplied to consumers. It is hoped that this research will contribute to improving the quality of electricity supply in Lusaka and further add to the existing body of knowledge on electricity service provision.

Abbreviations

BIS	Business Integrated System
BTOF	Behaviour Theory of Firms
CAIDI	Customer Average Interruption Duration Index
CBM	Condition Based Maintenance
DERP	Distribution Expansion and Rehabilitation Project
ERB	Energy Regulation Board
GDP	Gross Domestic Product
GWh	Giga Watt hour
HR	Human Resource
ICT	Information and Communication Technology
IMS	Incident Management System
ISO	International Standards Organization
KGRTC	Kafue Gorge Regional Training Centre
KWh	Kilo Watt hour
MEWD	Ministry of Energy and Water Development
MMS	Maintenance Management System
MWh	Mega Watt hour
MW	Mega Watt
O&M	Operations and Maintenance
PAS	Publicly Available Specification
PEMS	Plant and Equipment Management System
RCM	Reliability Centered Maintenance
RERA	Regional Electricity Regulators Association of Southern Africa
SADC	Southern African Development Community
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control And Data Acquisition
SSA	Sub-Saharan Africa
TBM	Time Based Maintenance

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Chapter 1: Introduction

1.1 Background

ZESCO Limited is Zambia's monopoly electricity service provider which is vertically integrated at generation, transmission and distribution. Even though the sector is unbundled at generation, ZESCO remains unequalled due to low private participation. Since the last two decades, ZESCO has been struggling to meet the rapidly growing electricity demand mainly due to energy intensive mining activities and growing household needs. Copper mining is Zambia's largest driver of the economy and is dependent on high energy intensive operations. According to the Energy Regulation Board (2014), the mining sector accounted for 55 percent of total electrical energy consumption. In the 2000s, Zambia experienced accelerated economic growth, largely due to a near fivefold increase in the price of copper which translated into the doubling of export volumes corresponding to a sharp increase in electricity demand following a long period of stagnation (Levy and Palale, 2014).

Zambia's urban population grew from 34.7 percent in 2000 to 39.5 percent in 2010. This represented an annual average growth rate of 4.2% between 2000 and 2010 compared to 1.5 percent between 1990 and 2000 (CSO, 2012). As a result of increasing demand due to expansion in the mining sector, manufacturing sector and overall economic and population growth the current national energy peak demand is estimated to be over 1,780MW while ZESCO's capacity to generate power is estimated around 1,700MW resulting in a deficit of 165MW considering that machines cannot be operated at full capacity in order to save them from damage (ZESCO, 2013). The rapidly increasing demand for electricity triggered by robust economic growth witnessed in the first decade of the new millennium however could not be met by the prevailing electricity tariffs which were below economic levels. As a result, investments in power generation, operations and maintenance of existing facilities was constrained resulting in declining power quality and reliability. This situation has culminated in load-shedding and power blackouts which have become an increasingly common phenomenon (Kapika and Eberhard, 2013).

On the other hand, operational inefficiencies of power utilities cost Sub-Saharan African (SSA) countries up to US\$ 3.3billion a year, thereby preventing investments in new capacity and electrification while power underpricing accounts for losses of up to \$ 2.2billion per year (Foster, V. and Briceno-Garmendia , C., 2010). In addition, generation capacity which is estimated at 125MW per million people generally ranks poorly compared to other developing regions such as Asia while about 25 percent of installed capacity is unavailable due to poor maintenance (Kapika and Eberhard, 2013). Further, utilities that operate below average efficiency are only able to electrify 0.8 percent of the population each year as opposed to 1.4 percent for utilities with above average efficiency (Foster, V. and Briceno-Garmendia , C., 2010). Ensuring full cost-recovery tariffs is essential in meeting the cost of new investments in power generation and electrification. Operational inefficiencies in SSA are mainly split between distribution losses which can be as high as 23.3 percent (more than twice the norm of 10 percent) and revenue under-collections that average 88.4 percent against a best practice of 100 percent. One direct consequence of insufficient revenue collection is poor maintenance (Foster, V. and Briceno-Garmendia , C., 2010).

In addition to problems of limited access; below cost recovery tariffs and; operational inefficiencies, utilities in SSA are faced with increasing demand for electricity. Market demand which consists of economic growth, structural changes and population growth is estimated to increase at a rate of 5 percent per annum in SSA reaching a peak of 680 terawatt-hours by 2015 (Eberhard, Rosnes, et al., 2011).

The main source of electrical energy in Zambia is hydro whose resource potential is estimated at 6,000MW of which only 2,257.5MW is currently utilized as installed capacity. Of the combined total installed capacity of 2398.39MW, 40.2 percent is concentrated in Lusaka province which is the most urbanized (ZESCO, 2013). Zambia's current energy mix is dominated by hydro at 94% of total installed capacity while other sources such as Gas, diesel, Heavy Fuel Oil and solar account for 3.3%, 0.45%, 2% and 0.003% respectively. Considering that 94 percent of electrical energy is from hydro makes the sector vulnerable to climate associated risks such as drought and heavy rainfall which have potential to adversely affect current and future generation capacity. Other sources of renewable energy such as sun and wind have not been fully exploited despite studies showing their potential. This is because currently, Zambia does not have a renewable energy policy and defined feed-in tariff to promote developments in renewable energy technologies to complement hydro generation (Policy Monitoring and Research Centre, 2014).

1.2 Problem Statement

Delayed investments in power generation plants due to a period characterized by a lack of demand prevented expansion of generation capacity. Consequently, ZESCOs weak financial position could not allow it to invest in expansion projects to serve rising demand in the last two decades (Kapika and Eberhard, 2013). This underinvestment became apparent from the subsequent high costs of on-going rehabilitation of power generation infrastructure (Levy and Palale, 2014). Moreover, projects being undertaken to increase generation capacity are only expected to be commissioned by 2019 (ERB, 2014).

On the other hand, ageing transmission and distribution facilities have suffered from inadequate operations and maintenance leading to high transmission and distribution losses thereby affecting the quality of electricity supply. The combined pitfalls both on the generation and distribution side collectively account for the energy deficit and resultant power outages being experienced in Zambia. However, due to limitations in time, the scope of this research will only focus on the service provider's shortcomings in its operations and maintenance activities as this is considered key in minimizing the current power outages at least in the short term. Interventions on the generation side which are capital intensive and require a long lead time are therefore considered medium to long term and beyond the scope of this study.

Currently, the service provider's immediate response to the increased demand has been to impose load-shedding which has resulted in the country experiencing prolonged periods of power outages. These planned power outages are based on a rotational schedule during periods of peak demand and are said to be necessary to safeguard the electricity infrastructure from damage (ZESCO, 2013). However, not all power outages are as a result of planned load management as faults on the lines and failure of equipment are also common due to the ageing and overloaded networks. Blackouts as such are also as a result of bottlenecks in the transmission and distribution network (ZESCO, 2014). Lusaka city which will be the study area of this research for instance constitutes 40 percent of the non-mining loads and is estimated to have a load demand growing at a rate of 6 percent per annum. According to ZESCO (2013), Lusaka's peak load for 2011 was 450MVA and projections are that this will increase to 1146MVA by 2030. Lusaka is serviced by old 132KV and 88KV transmission lines which provide thermal limits of 86MVA and 57MVA respectively (ZESCO, 2013). These two transmission lines have been outstretched by the increased demand and are pushed beyond safe operating capacity resulting in overloading and consequently periodic outages. This is as a result of inadequate investments in transmission and distribution networks which has led to depleted capacity in the system (Policy Monitoring and Research Centre, 2014).

The above scenario can be attributed to none cost reflective tariffs which have negatively affected operation and maintenance of existing infrastructure. In an effort to improve the operations of ZESCO, the Energy Regulation Board has since 2008 approved five tariff increases across four customer categories, namely; Residential; Commercial; Social Service and; Maximum Demand. Despite the increases, tariffs have still remained below cost recovery. The service provider however, has recorded improved financial performance whereas technical performance has deteriorated (Kapika and Eberhard, 2013). The deterioration in technical performance could in part be understood as resulting from low labour productivity. For instance, Lesueur and Plane (1994) argue that the aim of financial and economic reorganization of public utilities was to achieve an operational balance that did not rely on State intervention or tariff increases but on human resource management based on economic and not social considerations (Lesueur and Plane, 1994). In the case of ZESCO however, staff costs remain high, at over 50 percent of the total annual turnover (Levy and Palale, 2014). As such, one key performance indicator of ZESCO's performance is based on its customer-employee ratio which target was set at 100:1 to be achieved by 2012 as a measure to contain costs (Kapika and Eberhard, 2013). This customer-employee ratio in 2006 was 84:1 (Simwanza, 2006). Human resource therefore remains cardinal in addressing the financial and operational performance of ZESCO.

Based on the foregoing, it is clear that ZESCOs performance is being negatively affected, firstly by inadequate financial resources due to below cost tariffs and an inefficient human resource structure in terms of its customer-employer ratio leading to increased staff costs. These two factors can significantly affect operations and maintenance activities which in turn affects the quality of electricity supplied to consumers, resulting in unplanned power outages.

1.3 Research Objective

This research is being undertaken on the premise that ZESCOs performance is said to have deteriorated over the years despite the utility recording improvements in its financial performance (Kapika and Eberhard, 2013). The intention however of this research is not to measure the performance of the whole organization but instead to focus on the performance in terms of the quality of electricity supply which is directly influenced by operations and maintenance. Operations and maintenance on the other hand involves managing the physical assets used to deliver a service using softer elements such as knowledge, information and other aspects which are related to human resource management. Furthermore, financial resources are required to be able to deliver the service to the desired level. The objective of this research is therefore to explain the extent to which human resource and the current electricity tariffs have influenced ZESCOs operation and maintenance activities and whether this has led to an improvement in the quality of electricity supply in Lusaka, Zambia. In so doing, the study also aims to draw conclusions on the important factors that are key to operations and maintenance which influence the quality of electricity supply.

1.4 Main Research Question

“To what extent have *human resource* and the current *electricity tariffs* influenced the service provider’s *Operations and Maintenance* activities in improving the *quality of electricity supply* in Lusaka, Zambia”?

1.5 Sub Research Questions

- a. What factors of human resource influence operations and maintenance activities?
- b. To what extent do the current tariffs meet operations and maintenance costs?

- c. What are the critical factors of operations and maintenance and how do they influence the quality of electricity supply in Lusaka?

1.6 Significance of the Study

From a practical relevance point of view, this study will be useful for the service provider in making informed decisions on important aspects of human resource management that directly affect the performance of operations and maintenance activities. It will also assist key external stakeholders such as the Energy Regulation Board which approves and sets electricity tariffs in better understanding the challenges associated with below cost electricity tariffs and their impact on the quality of electricity supply to consumers whose interests they are mandated to serve and protect.

In addition to the above, this study will also add to the body of academic knowledge by highlighting some of the salient features of how state owned monopolistic service organizations have transitioned to operate under private sector business ideals. It will also identify the challenges that have come with commercialization of State owned parastatals with regards to performance when this was thought to be the cure for operational inefficiencies.

1.7 Scope and Limitations

This research seeks to explain the influence of human resource and the current electricity tariffs on operations and maintenance which consequently affects the quality of electricity supply to consumers. It is also acknowledged that the quality of electricity supply in terms of power outages is also affected by inadequate generation capacity which creates a demand-deficit resulting in load-shedding at peak times. The scope of this study is therefore limited to outages that are related to challenges in the transmission and distribution network which are directly linked to operations and maintenance. Addressing this portion of the network is considered appropriate as a stop-gap measure in the short to medium term as increasing the generation capacity may take long to come on board.

Another limitation of this study is that only human resource and electricity tariffs have been considered as important variables that influence operations and maintenance. Cognizance is given to the fact that there are several other aspects of asset management that work together to ensure that the service is delivered according to the desired level. These are explicitly elaborated through the organizational objectives model for asset management organizations developed by Esmaili (2012) which identifies three layers of the organization that affect its performance namely; technical; business and; informational activities. In addition to these, the model identifies external constraints such as legal, regulatory, political and customer expectations representing the context in which the organization operates (Esmaili, 2012).

Finally, according to the asset management framework by the Institute of Asset Management (2008), the successful management of physical assets is dependent on non-physical assets such as Human, Financial, Informational and Intangible assets. However, due to the limited time available for this research, only Human and Financial aspects were identified as key factors that influence operations and maintenance activities. Furthermore, it is acknowledged that human resource is a broad concept and as such only aspects to do with motivation, training, staff numbers and costs were considered in this research. Similarly, due consideration is taken of the fact that the service provider could have multiple sources of income such as grants, loans, export earnings and subsidies but only the current electricity tariffs are considered as these ideally should cover operating and capital expenditure.

Chapter 2: Literature review

2.1 Introduction

In order to meet development needs, developing countries need to increase access to reliable and clean energy sources. This is important as it is estimated that approximately 3 billion people globally rely on biomass for their cooking and heating needs and 1.5 billion lack access to electricity. In addition 1 billion people lack access to reliable electricity networks and suffer frequent blackouts (Mulugetta and Urban, 2010). Furthermore, about 25 percent of installed capacity is not in operation due to reasons such as ageing plants and lack of maintenance (Eberhard, Rosnes, et al., 2011). The situation is no different in Zambia where electricity blackouts have become a common phenomenon in the last few years.

The previous chapter stated in the problem statement, the challenges that ZESCO has been facing with human resource management and the current low electricity tariffs among the many factors that are influencing its operations and maintenance activities. Based on the main research question formulated; human resource; the current tariffs; operations and maintenance and; the quality of electricity supply were identified as the main variables of this research. This chapter will thus provide a theoretical background to the study and review literature related to the variables identified in this research. Furthermore, a situation analysis of ZESCO is given to have an appreciation of its internal and external business environment.

The objective of this research inevitably entails the study of human behavior since organizations are made up of individuals. This study therefore falls within the realms of organizational studies which has several theoretical underpinnings through which organizations can be studied. One such discipline is Organizational behavior which together with management theory are identified as most suited to this research and therefore will be used as the main theories grounding this study. The two theories therefore form the background to the literature review. Finally, the main theories and concepts and variables are used to formulate the conceptual framework showing the main indicators that will be used for measurement.

2.2 State of the Art of the Theories/Concepts of the Study

2.2.1 Behavioral Theory of Organizations

Business organizations are behavioral entities that differ in operational arrangements and cognitive division of labour and comprise of different hierarchical compositions, information access, incentives and span of control (Dosi and Marengo, 2007). Behavioral theories of organizations can be traced back to the book “A behavioral Theory of the Firm” by Cyert and March (1963). Although the book did not develop a behavioral theory of organizations per se, most theories based on behavior have emanated from it. In fact it is the most widely referred to research work influencing modern management. It has inspired and has become the cornerstone of new approaches to the study of organizations in management, economics, political science and sociology (Argote and Greve, 2007). Argote and Greve go further to state that the novel concepts and mechanisms have found their way into foundations of new theories, the reason why Cyert and March (1963) is held as a foundational piece in research traditions and organizational theory as a field. Concepts and ideas based on “A behavioral Theory of the Firm” underlie other theories within the scope of economics such as transaction cost theory and management and organizational sciences, for example resource based and capability based theories of the firm (Dosi and Marengo, 2007).

As a starting point to theory “A behavioral Theory of the Firm” takes a bounded rationality view of decision making and organizational behavior as core principles (Argote and Greve,

2007). In their work, Cyert and March sought to develop an empirically relevant general theory of decision making in a business firm which is process-oriented. The main decisions focused on in BTOF initially are price and output. According to Greve and Linda (unpublished) the ‘behavioral’ was initially not part of Cyert and March’s terms of reference in their work but because it involved studying the process of decision making, it had to focus on the process of actual decision making behavior. The process-oriented view thus inevitably entails studying multiple persons and consequently multiple organizational units engaged in decision making (Greve, H. R. and Argote, L., 2001). According to Cyert and March book, the problem solving processes of the firm are achieved through physical and cognitive acts within the procedure which results in the achievement of specific goals. They argue that ‘Behavior’ is motivated towards the achievement of goals which can be divided into sub-goals and further broken down into individual tasks (Greve, H. R. and Argote, L., 2001).

The tasks performed by individuals in organizations are interdependent and their accomplishment is dependent on the accomplishment of another. These interdependent tasks however should be coordinated or performed through routines. This concept grew out of the Behavioral Theory of the Firm’s operating procedure. According to Greve and Argote, Cyert and March (1963) used the concept of aspirations culminating from the organization’s past performance to develop goals. These goals are also influenced by the purpose for with the organization exists. Also theory acknowledges that organizations are made up of individuals whose contribution and performance requires motivation. According to BTOF, organizations respond to performance below their aspirations by constant problemistic searching based on past experience. In their book, Cyert and March found that a combination of physical and cognitive acts within a procedure form the basis of problem solving (Dosi and Marengo, 2007). Dosi and Marengo describe this as a ‘capability centered view’ of the business or firm which draws its roots in BTOF emphasis on viewing the organization as an “adaptive system” which relies on shortcuts, routines and standard procedures in problem solving (Dosi and Marengo, 2007)

In Cyert and March’s theory of standard operating procedures, organizational behavior is seen as having a high component of procedure following, which includes rules for performing tasks and information transfer. Based on the foregoing, it can be seen that the concepts of the BTOF can be applied to the case in point of this research. ZESCO as an organization is comprised of individuals that perform different interdependent tasks through routines for the achievement of its goals. Therefore studying the operations of ZESCO recognizes the role of individuals in delivering uninterrupted supply of electricity through efficient operations and maintenance activities as of utmost importance. This is consistent with Argote and Greve (2007) who state that it is less theoretically satisfying and less legitimate to make predictions about organizations without process justification in modern organizational theory (Argote and Greve, 2007). This according to them is an important aspect of the legacy of “A Behavioral Theory of the Firm”.

Finally, Argote and Greve (2007) criticize modern approaches to organizational theory which focus more on the external environment comparisons between organizations neglecting internal workings. They cite population ecology or institutional theory as examples of modern theories that fail to articulate internal environments. By contrast the work of Cyert and March examined both the internal and external workings of the organization. As an example they highlight the fact that organizations have multiple goals, some of which place them in contact with the external environment. They strongly encourage that developments in the field revive the interest in internal structures and processes of organizations (Argote and Greve, 2007). One weakness identified with this theory is the assumption that individuals behave rationally in the achievement of goals.

2.2.2 Management and Strategic Management

Though there is no one definition, management can be understood in terms of coordinating activities of Planning, Organizing, Motivating and Controlling (Cole and Kelly, 2011). Cole and Kelly (2011) also recognize that the classical definition of management by Fayol as “to manage is to forecast and plan, to organize, to command, to coordinate and to control” is still valid and adapted by many scholars to this date.

The theory of modern management adopted in the later part of the twentieth century is concerned with organizational effectiveness just as much as it is concerned with efficiency. According to Cole and Kelly (2011), efficiency is concerned with ‘doing things right’ while effectiveness focuses on ‘doing the right things’. That is to say that effectiveness goes beyond efficiency which was the preoccupation of early classical theory approaches. Modern management theorists thus adopt a strategic focus to organizational management. Strategic mission, values and organizational culture are some of the objectives of modern management. Promoting organizational excellence, total quality management and stakeholder engagement are also enshrined in modern management practice. In Bratton and Gold (2012), a strategy is seen as a specific pattern of actions undertaken by managers in achieving superior performance objectives. The pursuit for superior performance should continuously be monitored and adjustments made to goals based on opportunities and threats posed by the organizations external environment. These should be weighed against the organization’s Strengths and weakness. These approaches are seen to be consistent with contingent management theorists who viewed organizations’ as open systems affected by their external environments. This is also consistent with modern management theory where organizational excellence is seen as a key driver of strategic management.

2.3 Human Resource Management

Human resource management according to Itika (2011) is a discipline and practice that has developed and evolved due to environmental circumstances and the desire to better understand ways of acquiring and utilizing labour. Manager’s aim to improve efficiency in the service delivery process by adapting to the changing organizational environment in the marketplace by enhancing their abilities of people management using best practices available. This involves employing techniques of employee management that would improve production and reduce costs as well as ensure sustainability in terms of retaining competent staff in the organization (Itika, 2011). This section therefore looks at the main aspects of human resource management that influence organizational performance.

2.3.1 Skills, Knowledge and Training

Simwanza (2006) in his study, found that ZESCO had a highly qualified and experienced workforce with 3,666 employees in total. Of the 3,666, there were 182 engineers, 152 technologists, 266 technicians, 628 craftsmen, 197 accountants and 2181 other disciplines which resulted in an employee-customer ratio of 1:84 (Simwanza, 2006). However, training and continuous development is an on-going process so that employees are kept abreast with their skills as they operate in a dynamic environment with constantly changing technology. It is therefore prudent to have them trained both in their line of work and for future prospects. According to Esmaili (2012) asset management staff must be adequately trained to ensure they are up to date with their competencies as demanded by their role. For this reason, this research will include the aspect of training of human resource involved in operations and maintenance to be studied as this has an effect on ZESCO’s performance. Therefore, a review of literature on Skills, Knowledge and Training has been undertaken in an attempt to understand its influence on operations and maintenance.

The late 1970s and early 1980s saw a movement in which corporations' personnel departments moved to being called "human resources" departments. This transition was evidence that employees were no longer being seen as just costs but as assets which could generate revenues and profits (Liu, Combs, et al., 2007). Despite this, Liu, Combs, Ketchen, Ireland (2007) acknowledge that investments such as training and incentives for human resources are highly visible in comparison to the return on the investments making it difficult to measure the value of investing in human resource. According to Itika (2011), organizations should have an explicit policy on training and development which shows their commitment to provide continuous training and development of human resources designed to maximize employee potential.

According to Liu, Combs, Ketchen, Ireland (2007), considerable time and effort has been spent by researchers in trying to understand exactly the conditions under which investments in human resource management enhance a firm's performance. Based on theory, they identify three main ways by which a firm's performance is shaped by human resource practice namely; increase in employees' Knowledge, Skills, and Abilities (KSAs); motivate employees' knowledge, skills, and abilities; and empower employees to do so. They state that a high level of Knowledge, Skills and Abilities is required for employees to perform effectively. Further they argue that employees must be motivated to make significant contributions beyond their tasks. This can be achieved by ensuring that employees are equipped with the requisite KSAs to step beyond the routine.

Dhar (2015) in his findings concluded that the commitment level of employees is influenced by the organizations support for training and making it accessible to employees. This makes employees feel attached to their organization. He further argues that by supporting training, an organization portrays its commitment towards the quality of service it wants to offer to its customers (Dhar, 2015). In short he found that employee commitment was strongly correlated to various training activities offered by their organization. However, not all training offered by organizations was relevant to enhance employee efficiency and performance.

Therefore, it is important that organizations offer relevant training to employees to increase commitment as well as improve performance (Dhar, 2015). These findings are consistent with Tech-Hong and Yong-Kean (2012) who state that employee training must have the full support of the employer to ensure success and participation by the entire organization. They further state that top management should offer a broad spectrum of training programs to cater for varying needs of employees at different levels (Tech-Hong and Yong-Kean, 2012). Dhar (2015) in conclusion calls for further research in this field to include cultural values.

2.3.2 Productivity and performance management

According to Itika (2011) productivity is an indicator used to measure how best resources in an organization are utilized based on set performance targets, standards and measurements. This forms the basis for acquiring the right skills, numbers and incentive based rewards. Performance assessment is therefore important in knowing whether or not a department or section is achieving its objectives (Itika, 2011). A performance agreement is signed between a line manager and employees as a basis for individual performance appraisal and the rewards based on performance.

According to Lesueur and Plane (1994), increasing the proportion of middle managers in an organization develops supervisory functions to lower-echelon workers thereby increasing their productivity. This also allows middle managers to motivate the lower level employees. However, the aim of streamlining operations is to introduce incentive mechanisms so that employees' wages and other benefits are result oriented (Lesueur and Plane, 1994). This was the human resource management strategy adopted by utilities in the later 1980s where the

increase in middle managers resulted in the decline of operatives in order to stabilize operating accounts. They further state that in order to stimulate productive behavior and encourage loyalty among skilled workers, the World Bank recommended the introduction of performance oriented pay systems (Lesueur and Plane, 1994). Previously, utilities simply raised wages uniformly across the board.

2.3.3 Organizational culture

Organizational culture according to Itika (2011), can have different interpretations. He however argues that organizational culture develops over time and involves beliefs, norms, attitudes, authority, obedience by subordinates, punctuality and adherence to rules and regulations. Katongo (2006) found that ZESCOs corporate culture was influenced by the nationwide culture of state owned utilities which were faced with perpetual complaint resolution problems stemming from the past. He therefore commends attempts to help employees in understanding what is expected of them (Katongo, 2006). Furthermore, Katongo (2006) in quoting a ZESCO Newsletter of 2006 where then Managing Director, Rodney Sisala emphasized that attitudes drive behavior of individual employees and that it is only a positive attitude that individual performance could be enhanced to contribute towards the achievement of organizational goals.

2.4 Electricity Tariffs and Cost recovery

In order to meet its mandate, ZESCO as a commercialized entity must fully recover its costs by charging cost reflective tariffs for its commodity (electricity). Low tariffs have hindered investments to increase generation capacity and meet operations and maintenance needs. According to the Policy Monitoring and Research Centre (2014), cost reflective tariffs are a mechanism to recover costs incurred in the production of electricity. Cost recovery ratio is an indicator used to measure a utilities operating expenses against its revenue. According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), the ratio can be measured as a ratio of the effective tariff to cost per KWh and is expressed as a percentage. This reflects the price-cost relationship which takes care of both operational and capital components. The cost recovery ratio reflects the utility's ability to cover its operating expenditure by its revenue. In their study of 21 SSA countries, Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) found that only 10 had tariffs covering operational costs and only 6 of these covered total costs. They further state that some tariffs in comparison with more developed regions are high in relation to the levels of income. As such, losses in the sector can only be reduced by minimizing costs as further increases in effective tariffs may not be affordable. Zambia's total cost recovery was recorded to be the worst among countries surveyed at 38 percent (Tallapragada, Shkaratan, et al., 2009).

Another indicator used to determine whether operating expenses are covered by revenues realized is the ratio of operating costs to revenue billed and is expressed as a percentage. This however does not consider the utility's efficiency in the number of days of accounts receivables (Tallapragada, Shkaratan, et al., 2009). It measures the utility's ability to recover its current expenditures at the existing consumption levels and tariffs. An operating expenses ratio of less than 100 percent indicates operational costs are covered by revenues. In order to cover capital costs in addition to operating expenses, including non-collection, this indicator should be below 100 percent. However, Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) argue that many cost drivers and levels of collection can be optimized to improve operating expenses against revenue indicator by increased utility efficiency.

In determining tariff levels electricity sector regulators commonly use the revenue-requirement model. According to Ortega, Arriaga, Abbad, and Gonzalez (2008), the revenue-requirement should be based on the cost-causality function which is the analysis, identification and quantification of the cost drivers. These should include an assessment of the network

investment, operations and maintenance costs, quality of service, commercial costs and other costs. Under operations and maintenance, assets require to be maintained in order to perform to their expected service life. Maintenance costs are assumed to be directly proportional to the network investment. Operational costs on the other hand are considered to be proportional to the number of customers served (Ortega, Arriaga, et al., 2008). Commercial costs refer to the administrative costs involved in dealing with the customer and are usually related to the number of customers and their size. Other costs relate to requirements of the utility such as buildings and staff costs.

According to Ortega, Arriaga, Abbad, and Gonzalez (2008), the whole point of deregulation of the electricity sector is to increase efficiency by unbundling activities and introducing competition. They however acknowledge that in countries where unbundling has been done, transmission and distribution still remain a natural monopoly. They state that traditionally, electricity tariffs were meant to recover the entire costs of producing power altogether without assessing costs of each activity involved. However, they argue that there is need to unbundle electricity tariffs, where each activity involved has its own costs to be recovered and its own tariff design methodology (Ortega, Arriaga, et al., 2008). They cite well designed distribution tariffs as capable of driving a more efficient system by shifting consumers' consumption patterns thereby allowing the utility to delay system reinforcements and investments in new generation. The difficulty with designing distribution tariffs however is the huge amount of assets associated with the distribution system and determination of the efficiency of each component (Ortega, Arriaga, et al., 2008).

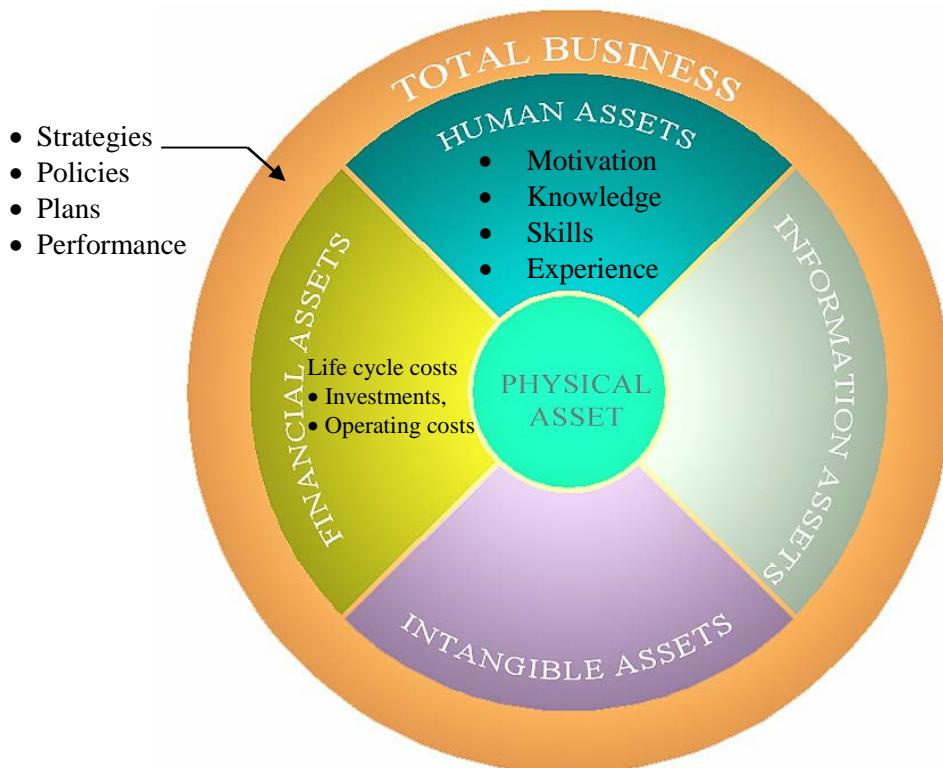
2.5 Operations and Maintenance (Asset Management)

As outlined by Schneider, Gaul, Neumann, Hografer, et al. (2006), electricity networks degrade over time due to ageing infrastructure which has a negative impact on performance of the network making it difficult for performance targets to be attained. Investments are dependent on the availability of financial resources which are also tied to customers' willingness to pay. According to Schneider, Gaul, Neumann, Hografer, et al. (2006), utilities need to develop the ability to evaluate the dependencies between maintenance, rehabilitation, costs and the quality of service. By developing these competencies, asset managers are able to sustainably develop the grid by directing resources to ensure long term as well as short term objectives are met.

The Institute of Asset Management (2008) defines asset management as "*systematic and coordinated activities and practices through which an organisation optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan*".

The management of assets in a service organization can be understood using figure 1 which is adapted from the Institute of Asset Management's PAS 55-1:2008. According to this framework, the successful management of physical assets is dependent on other non-structural assets such as human, financial, information, plans and so on. This is also consistent with Esmaili (2012) who found that asset management goes beyond just the technical activities to include business (organizational) and information management processes as well as proactive management of people. Figure 1 therefore illustrates the interaction of non-structural assets with the physical assets that constitute the organizations technical activities.

Figure 1: Physical assets relationship with other assets



Source: Adapted by the author from the Institute of Asset Management's PAS 55-1:2008

According to Schneider, Gaul, Neumann, Hografer, et al. (2006) asset management relates to operating a group of assets over the whole technical life-cycle to guarantee a suitable return to shareholders and to ensure a defined level of service and safety standards. Therefore the aim of asset management is to optimize the utilization of the remaining life time based on a stipulated reliability of the service and constant distribution of costs for reinvestment and maintenance to ensure a suitable return. They argue that in order to balance between returns and service quality, operators need to develop 'best practices in asset management.

2.5.1 Asset Management Strategies, Policies and Plans

The Institute of Asset Management (2008) recommends that organizations have a long term asset management strategy endorsed by senior management and aligned to the organizations strategic plan. This strategy should consider the requirements of the relevant stakeholders and should be communicated accordingly. It should also be reviewed periodically and be consistent with other policies within the organization (The Institute of Asset Management and British Standards Institution, 2008). The organizations asset management policy should be authorized by top management and should be derived from the organizations strategic plan. It should among other things be consistent with other company policies and should include a commitment to comply with any legislation and regulatory requirements.

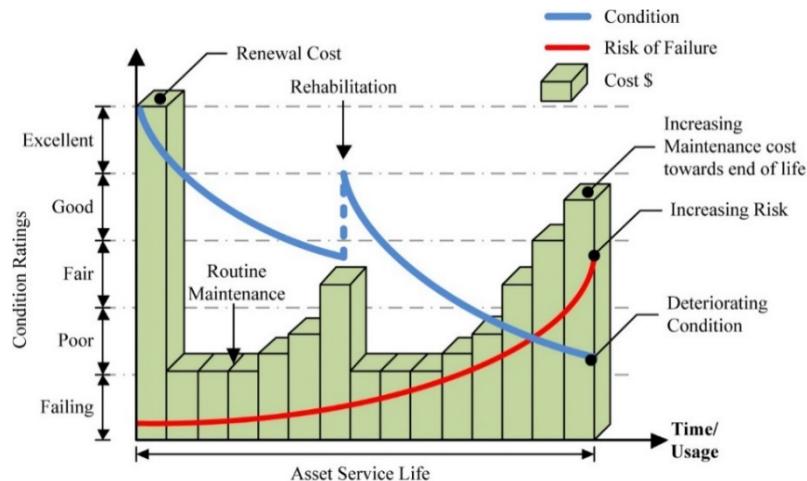
The organization should also establish, document and maintain Asset Management Plans to implement the asset management strategy throughout the life cycle of the asset. Plans shall also be communicated to relevant stakeholders according to their level of interest in the business (The Institute of Asset Management and British Standards Institution, 2008). They further indicate that asset management plans should include; specific tasks and activities; responsibilities and authorities and; the means and time scale within which the plans will be achieved. Finally, they state that the ultimate aim of the plans should be to improve the system.

The above is in a way consistent with Esmaili (2007) who argues that Strategies, Policies and Plans should form a direct communication tool to staff, stakeholders and consumers. He further finds that these policies, strategies and objectives should be reviewed regularly to ensure that there are no conflicts that with other organizational units (Esmaili, 2012).

2.5.2 Maintenance

Ageing equipment in power system components is a fact of life in the electricity sector. The probability and frequency of failure increases as a piece of equipment becomes old thereby requiring more repair time. Maintenance can considerably extend the service life of a piece of equipment. However, this becomes costly as the equipment nears its end life (Abu-Elanien and Salama, 2009). Esmaili goes further to say that an assets finite life is directly related to the quality and quantity of maintenance and rehabilitation. He also notes that as the asset nears its end life, the risk of failure and the cost to maintain it significantly increases (Esmaili, 2012). Figure 2 shows increasing maintenance costs as an asset nears its end life whereas the risk of failure also increases.

Figure 2: Lifecycle maintenance costs of an asset



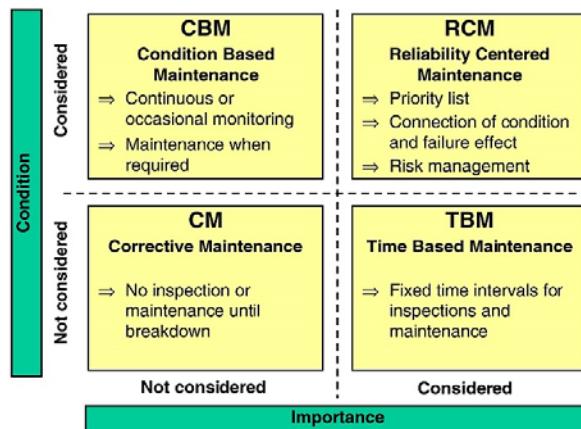
Source: Adapted from AMCL, cited in Esmaili (2012)

Similarly, as illustrated in figure 2, ZESCO's electricity network suffers from ageing transmission and distribution infrastructure. This has resulted in unplanned power outages as a result of bottlenecks within the network. This entails that the utility should ideally adopt a rigorous maintenance regime which would inevitably result in increased maintenance costs based on the condition of its infrastructure.

2.5.3 Maintenance Strategies

The term 'strategy' according to Fernandez and Marquez (2009) can be defined as "a unique and valuable position, involving a different set of activities". However a strategy goes beyond just a plan of activities to reflect a pattern of an organization's goals and policies (Fernandez and Marquez, 2009). Based on the literature reviewed, there are four main types of maintenance strategies employed by utilities namely; Corrective Maintenance (CM), Time Based Maintenance (TBM), Condition Based Maintenance (CBM) and, Reliability Centered Maintenance (RCM). All three apart from CM fall under preventive maintenance which aims to prevent failure from occurring. Preventive maintenance also guarantees long life of the asset (Abu-Elanien and Salama, 2009). According to Schneider, Gaul, Neumann, Hografer, et al. (2006), two parameters commonly used to classify maintenance strategies are the component's condition and its importance in service reliability as illustrated using the matrix in Figure 3.

Figure 3: Classification of maintenance strategies



Source: Adopted from Schneider, Gaul, Neumann, Hografer, et al. (2006)

Under CM, there is no preventive maintenance involved. The component is operated until failure occurs, after which either repair or replacement is decided (Schneider, Gaul, et al., 2006). However, Francisco et al (2009) define CM as interventions carried out on the network to remedy or mitigate incidences producing a degraded service. This somewhat implies that the component is still in operation but not able to deliver at the desired level. Abu-Elanien and Salama (2009) on the other hand are consistent with the notion that CM is designed to perform maintenance on a component after failure has occurred. They go further to state that this type of maintenance may lead to catastrophic outcomes and in some case lead to losing the asset. According to Abu-Elanien and Salama (2009), this is the least expensive type of maintenance whereas, Schneider, Gaul, Neumann, Hografer, et al. (2006), argue that this is not the least cost strategy as the damaged components could prove to be more costly in the end than by employing a more appropriate strategy. It is generally agreed though that this maintenance strategy can be used on components that have no serious repercussions on system reliability such as small accessories.

TBM is based on inspection and maintenance of components at specific time intervals. This is a widely used strategy as has been suggested from the reviewed literature. Fixed time intervals are decided for inspections and certain maintenance works based on either the manufacturer's instructions or the experience of the operator. Most utilities currently use this strategy in maintaining their assets. Abu-Elanien and Salama (2009) however warn that as much as this strategy may prevent failure, it may also cause unnecessary outages, waste manpower, time and money if the maintenance intervals are too short. CBM on the other hand prioritizes condition over importance of the asset according to figure 3. Here the maintenance is triggered by built in sensors in the component when the condition reaches certain thresholds (Schneider, Gaul, et al., 2006). This leads to less down-time and moderate costs and is highly desirable, prioritization based on financial and logistical issues. Its aim is to reduce the continuous condition monitoring by using advanced online techniques which eliminating complete failure risk.

Finally, RCM (initially developed for the aviation industry) aims to preserve the function of a system at reasonable cost. It can be seen as a combination of more than one maintenance strategy optimized in order to minimize or avert risk. Identification of risk of each possible fault is therefore crucial in order to apply the appropriate maintenance actions. Successful implementation of RCM depends on the identification and prioritization of failure modes and their consequences on the system followed by modelling the probability of failure (Abu-Elanien and Salama, 2009). Low risk components are separated and treated with low cost strategies such as CM. Meanwhile, high risk components are treated with either CBM or TBM.

In summary, according to Schneider, Gaul, Neumann, Hografer, et al. (2006), challenges facing current asset managers are not so much on the methods of applying asset management but ICT to support asset management decisions. They argue that maintenance related data and reports are found in databases that are not connected with work management systems which hampers the task of asset management. Thus, there is a need for integration of systems for effective decision making. They also highlight the challenge of misapplication of resources meant for operation and maintenance.

2.5.4 Key operational efficiency Indicators

According to Eberhard, Rosnes, Shkaratan, and Vennemo (2011), conventional measures used to determine reliability of power systems are; unplanned capability loss factor (UCLF) of generators; number of transmission interruptions and; indices of the frequency and duration of interruptions (Eberhard, Rosnes, et al., 2011). One of the indicators used to measure system losses within the transmission and distribution network is the; total system losses measured as a percentage. According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), Total system losses is an important indicator used to measure all losses that occur during transmission and distribution. The indicator is measured as the difference between the total power (GWh) supplied for consumption within the country and the power (GWh) billed to customers represented as follows:

$$\begin{aligned} \text{System losses} = & (\text{In-country generation, net of power plant own use (GWh)} - \text{Export (GWh)} \\ & + \text{Import (GWh)} - \text{Electricity billed to customers}) / (\text{In-country generation, net of plant own use (GWh)} - \text{Export (GWh)} + \text{Import (GWh)}). \end{aligned}$$

Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), state that system losses can be divided into technical (heat/copper losses, magnetic losses or transformer losses) and non-technical losses otherwise known as commercial losses. In commercial losses, meter failure, meter tempering of fraud, illegal connections and data encryption losses in billing are possible causes (Tallapragada, Shkaratan, et al., 2009). They argue that this is a more reliable indicator than Technical and Non-Technical losses which can be difficult to separate. They further state that this is one of the most important indicator of the power sector in developing countries in that it provides information on system efficiency and overall performance of the utility in terms of supplied energy and billed energy. This is particularly applicable to Zambia, where the utility is vertically integrated, meaning that total system losses equal combined transmission and distribution losses. One major disadvantage of using this indicator is that while it provides for an overall estimate of system efficiency, it does not help to identify the sources of inefficiencies as it combines both technical and non-technical losses (Tallapragada, Shkaratan, et al., 2009). According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), the optimal range of total system losses is typically between 7 percent and 10 percent in developed countries whereas this is below 20 percent in developing countries.

Another important indicator used to measure how efficiently a utility uses its power system equipment is the load factor. This is a ratio of the average annual load to maximum annual load and measures how much power is supplied on average per unit of peak demand (Tallapragada, Shkaratan, et al., 2009). It helps to determine how close the power supply system is being overloaded meaning that when the load factor is high, the average is only marginally below peak demand and equipment usage efficiency is high. However, this means that the system capacity is close to its capacity limit and is at risk of collapse with potential increase in peak demand (Tallapragada, Shkaratan, et al., 2009). The following is the formula for computing the Load Factor:

$$\text{Load Factor} = (\text{Annual electricity supplied (MWh)} / (24\text{hours} * 364\text{days})) / \text{Peak annual demand (MW)}$$

Load Factor according to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), is an important indicator for African utilities to reduce costs of producing and supplying power as it points to where equipment efficiency could be increased.

2.6 Quality of electricity supply

According to Holt (2005), utilities have transitioned from ‘rate of return’ to ‘price cap’ or variants imposed by their regulators. Traditionally practiced price regulation is changing to allow utilities flexibility in investing in operations and infrastructure. Holt states that without quality regulation, price regulation may influence utilities in either over supplying quality in the case of rate-of-return which affects quality or underinvesting to maximize profits thereby compromising in the case of price-cap regulation (Holt, 2005). Holt (2005) describes the quality of service supplied by a utility to be the delivery of services to consumers including activities preceding and following service delivery including network components (hardware and software) through which the service is provided. Holt also states that quality of service standards can be expressed in terms of performance measures such as the time it takes to restore power following an outage.

Performance measures set by regulators as formal targets to be met by utilities are often based on a well-conceived set of quality of service criteria. According to Holt (2005), measuring the quality of service is usually complicated as it comprises of different dimensional attributes whose importance is perceived differently by customers. Reliability for example is perceived to be valued more than say availability of payment options. Where significant rate adjustments do not occur for a considerable period, utilities may be inclined to enhance their revenue by minimizing operating costs and capital investments thereby compromising service quality (Holt, 2005).

According to Holt (2005) quality of service refers to technical, commercial and commodity standards. Technical standards are concerned with issues of reliability such as the number and duration of service interruptions whereas commercial standards are concerned with the direct transactions between the utility and the customer. All these standards are expressed as measures which determine the minimum performance level set by the regulator and expected of the utility (Holt, 2005). However, Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) found that the two most important indicators in measuring service quality are; number of outages which are technical parameters and; number of days of delay in obtaining electricity connection which refer to commercial standards. However, for purposes of this study, only quality of service in relation to the number of outages (technical standards) will be considered. Further, the quality of power supply refers to power reliability which is commonly associated with the frequency of power interruptions (Tallapragada, Shkaratan, et al., 2009). Therefore the number of outages per year is the main indicator of service quality particularly in Africa where outages are common in comparison to other regions (Tallapragada, Shkaratan, et al., 2009).

According to the Policy Monitoring and Research Centre (2014), key performance indicators are a set of quantifiable measures used by an organisation to gauge or compare their performance in terms of achieving their strategic and operational goals. They further state that an organization may use this to evaluate its success and progress towards organizational goals. Table 1 shows ZESCO’s key performance indicators against which the Energy Regulation Board measures its performance in improving operational efficiency and quality of service (Policy Monitoring and Research Centre, 2014). The main indicators that will be used to measure the construct of this research are shown in the shaded area in table 1.

- (i) *Cost containment* – customer employee ratio; staff costs; transmission losses and; distribution losses.

(ii) *Quality* – The number of system and customer interruptions and; the duration of interruptions measured by reliability indices shown in the table.

Table 1: Key performance indicators for ZESCO (2011-2014)

Performance indicator	Target measures
New connections and metering	All standard new residential connections to be made within 30 days after payment has been received from the consumer Install 25 000 pre-paid meters per quarter All unmetered consumers to be metered by 2013
Collections	Reduce non-government debtor days to not more than 60 days by March 2013 Reduce government debtor days to not more than 90 days by March 2013
Debt/equity ratio	Move debt/equity ratio to 70:30 by March 2016
Cost containment	Improve customer-employee ratio to 100:1 by March 2012 Reduce staff costs to 45% of operating costs by March 2013 Maintain transmission losses to 5% or less Reduce distribution losses to 14% by March 2012
Quality (maximum levels applicable from April 2011)	Dry season SAIDI _{DS} – 27 hours Wet season SAIDI _{WS} – 36 hours SAIFI _{DS} – 5 times SAIFI _{WS} – 5.5 times CAIDI _{DS} – 5 hours CAIDI _{WS} – 7 hours ASAI – 90%

Source: ERB, personal communication (2012)

Note: SAIDI = $\frac{\text{Total customer hours of interruptions}}{\text{Total customers served}}$

SAIFI = $\frac{\text{Total customer interruptions}}{\text{Total customers served}}$

CAIDI = $\frac{\text{Total customer hours of interruptions}}{\text{Total customer interruptions}}$

ASAI = $\frac{\text{Interrupted customer hours}}{\text{Available customer hours}}$

Source: Kapika, J. and Eberhard, A., 2013.

2.7 ZESCO Situation Analysis.

As a commercialized utility, ZESCO in its quest to achieve its strategic objectives, is guided by a mission, vision and strategy in the management of its operations approach. As can be seen in its mission, the utility aims to improve its service provision in terms of the quality of electricity supplied to its consumers. Further, the utility's vision is focused on improving its effectiveness through a dedicated and motivated workforce in line with the tenets of strategic management. Below are the mission, vision and strategy of the utility.

The utility's current mission statement is:

“To provide safe and reliable electricity to improve the quality of life for all”.

Its vision is:

“To be an effective service provider through a highly motivated team driven by a passion for innovation and excellence”.

And its strategy is:

“To run ZESCO as a profitable business which is customer focused”.

According to Simwanza (2006), ZESCO's management in its Business Plan (2004-2009) following the analysis of its internal environment undertook to pursue the following strategic issues among others:

- Generate enough revenue to support operations.

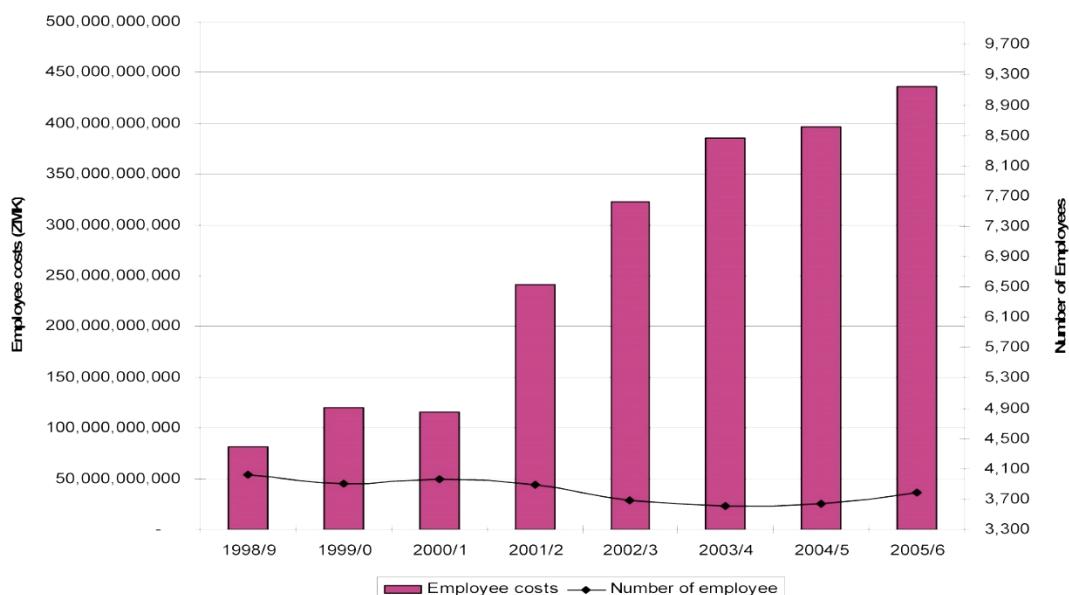
- Address the excessive cost structure of the organization.
- Improve efficiency in the distribution system.
- Effective operational/organizational structures.

It is from the above mission and strategy that this research attempts to explain the extent to which the variables defined influence ZESCO's mission to provide safe and reliable electricity to its consumers. The strategic issues listed above are not exhaustive but are in line with the purpose of this research. It is therefore critical to look at the utility's operations and maintenance activities which hinge on human capital and revenue to enhance the quality of electricity supplied to its consumers.

2.7.1 Staff Costs

ZESCO has from time before its commercialization been a subject of public concern over its high staff costs. This stems from the fact that ZESCO since the 1980's had among the lowest tariffs in the world due to excess generation and inelastic demand. With excess generation capacity and a flat demand, ZESCO at the time saw no incentive to invest in new infrastructure and operations and maintenance. As a result electricity tariffs were kept as low as US\$ 0.03 per kilowatt-hour which revenue went to meet staff costs (Levy and Palale, 2014). According to Levy and Palale (2014), ZESCO's wage bill continued to be high even after its commercialization, amounting to over 50 percent of its total annual income based on its 2005 report. The number of employees had risen from 4,000 in 2002 to 5,000 in 2006 (Levy and Palale, 2014). The increase accounted for about 1,200 temporary full – time employees. According to a cost of service study conducted by Deloitte in 2007, ZESCO's staff costs had escalated at such a rate that they seemed unsustainable going forward. In 2004, staff costs accounted for 50 percent of the utilities total costs. The staff costs include basic pay, overtime, allowances (housing, travel, medical, hardship, inducement, transport, standby and shift allowances), leave pay, pension contributions, funeral grants and retirement benefits (IPA Energy Consulting, 2007). Whereas there was a decrease of about 2 percent (from 3,941 to 5175) in the number of permanent employees between 1999 and 2004, staff costs were increasing as can be seen in figure 4.

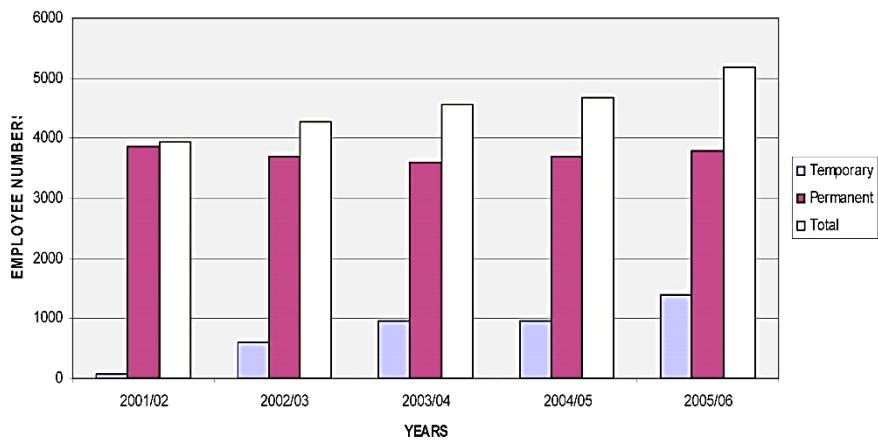
Figure 4: Changes in staff costs vs staff numbers (1999 – 2006)



Source: IPA Energy Consulting 2007

According to the IPA (2007) report, full time temporary employment increased from 82 to 1,390 and total full time employment rose from 3,941 to 5,175 as shown in figure 5. It can be seen that whereas permanent full time employment has been contained, full time temporary employment is rising rapidly and was representing about 27 percent of ZESCO's total employment by 2007 (IPA Energy Consulting, 2007). Based on their findings, IPA Energy Consulting concluded that the issue was not the average cost but the large numbers which were increasing and affecting overall productivity and efficiency. They stated that the temporary employees were somehow employed on a virtually permanent basis and that ZESCO would in future be pressured to convert them to permanent status which would entail further cost increases (IPA Energy Consulting, 2007). Figure 5 shows employment numbers for permanent full time employees against growing full time temporary employment numbers.

Figure 5: ZESCO Employment 2002 - 2006



Source: IPA Energy Consulting 2007

ZESCO compared with South Africa's ESKOM (a large utility which underwent restructuring) and Mozambique's EDM which has about the same customer base as ZESCO was found to have a lower customer per employee ratio. However, ZESCO's average cost per employee was 64 times the country's GDP per capita while ESKOM's average employee received 9.5 times South Africa's per capita GDP. Mozambique's EDM employee received 39 times Mozambique's GDP per capita. This revealed that the Zambian average ZESCO employee was highly paid within the context of the Zambian economy (IPA Energy Consulting, 2007).

The above scenario can be explained by Lesueur and Plane (1994) who found that most utilities studied in the 1980s had marginally reduced employment of permanent workforce as a way of controlling their wage bills but increased their contractual labour which in some cases rose from 1 to 20 percent of the workforce. This is because a reduction in staff numbers may be compensated by using temporary labour during retrenchment exercises. However, this trend requires evaluation of both its economic effectiveness and social costs (Lesueur and Plane, 1994). They further state that this secondary market of temporary employees consists of workers that do not possess any real qualifications and the most they get is fixed – term contracts and do not fully identify themselves with the organization. These workers however are expected to perform tasks that are of a one-off nature in an attempt to reduce labour costs. This in essence is expected to increase economic efficiency.

2.7.2 Determination of Tariffs

Electricity tariffs in Zambia are determined by the Energy Regulation Board (ERB) on the basis of an application made in the prescribed format by the service provider (Kapika and Eberhard, 2013). Currently, the determination of tariffs by the ERB is based on the revenue-requirement

method which is embedded in the cost of service model which in theory should allow for full cost recovery (Kapika and Eberhard, 2013). This was based on the government's goal to achieve cost reflective tariffs by 2011 following the commercialization of ZESCO though this has not yet been attained.

2.7.3 Barriers in attaining cost reflective tariffs

According to Levy and Palale (2014), utilities and regulators in all countries encounter tensions in balancing the preferences of low tariffs by their consumers and the economic imperatives of the utility. In Zambia however, the combination of the economic demands of the sector and the dynamics of Zambian politics made this tension even more intractable (Levy and Palale, 2014). Based on their argument, whereas an efficient electricity network could be able to supply power to residential consumers at a price equal to about twice the cost of generation, this fell way below in the case of ZESCO. For example at a generation cost of US\$ 0.04/KWh, the ideal retail price to households would be US\$ 0.08/KWh. Estimates however indicate that the cost of new hydro generation power to meet increased demand amounted to US\$ 0.06-0.07/KWh as of 2007 (Levy and Palale, 2014). This represents a cost-efficiency marginal cost of supplying power to consumers of about US\$ 0.11 to 0.13/KWh. This was against a background where Zambians had already been accustomed to paying very low rates for power at US\$ 0.03/KWh. Consequently, increasing this to a price capable of supporting system expansion was naturally a big challenge (Levy and Palale, 2014).

Based on the above, politics suggested that realigning residential tariffs would be extremely difficult as political leaders sought to orchestrate political control without irking urban residents. Kapika and Eberhard (2013) in their analysis of the tariffs in Zambia also suggest that it will take time to reach cost reflective tariffs and acceptance by consumers based on low tariffs from the past. Holt (2005) also notes that customers may resist both the quality of the existing service and any efforts to improve the existing service making it political (Holt, 2005).

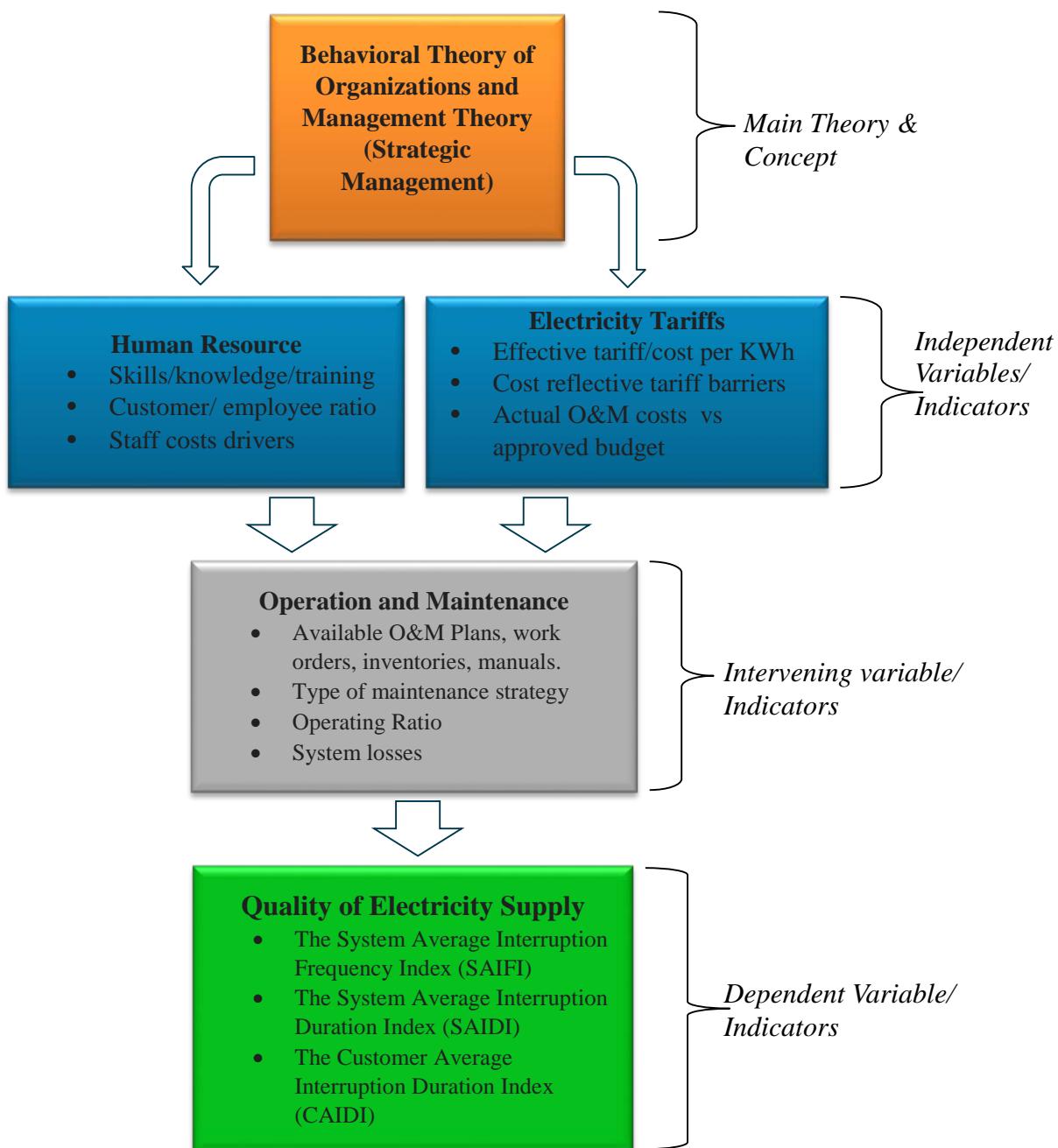
2.7.4 Financial and technical performance

While its financial performance was seen as less than stellar in the 1990s, ZESCO was before then considered a regional powerhouse in terms of its capacity to export electricity (Kapika and Eberhard, 2013). However, this changed when the country saw rapid development of mines and a growing population thereby creating increased demand. In two decades, the country moved from having a flat demand, to situation where lack of funds were preventing it from investing in new generation projects to meet increased demand. The low tariffs at the time also prevented ZESCO from investing in the existing transmission and distribution infrastructure which now due to ageing lines and transformers has become constrained and unreliable. This has led to the country experiencing frequent power outages which were unheard of in the early 1990s. Following its commercialization due to structural adjustment reforms, the utility had since shown an improvement in its financial performance, whereas its technical performance had deteriorated (Kapika and Eberhard, 2013).

2.8 Conceptual framework

The overarching theory used for this research is the behavioral theory of organizations which together with management theory and the concept of strategic management form the theoretical framework of this chapter. The variables identified in the literature based on the main research question are; Human resource; electricity tariffs; operation and maintenance and; quality of electricity supply. Human resource and electricity tariffs are the independent variables identified whose influence on operation and maintenance (intervening variable) consequently affects the quality of electricity supply. The dependent variable in this case is the quality of electricity supply which is measured by reliability indices as shown in the conceptual framework in figure 6.

Figure 6: Conceptual framework



Notes

SAIFI – $\Sigma (N_i) / NT$
 Ni = Total no. of customers interrupted
 NT = Total no. of customers served

SAIDI – $\Sigma (r_i * N_i) / NT$
 ri = Restoration time, minutes
 Ni = Total no. of customers interrupted
 NT = Total no. of customers served

CAIDI – $\Sigma (r_i * N_i) / \Sigma (N_i)$
 ri = Restoration time, minutes
 Ni = Total no. of customers interrupted

Chapter 3: Research Design and Methods

3.1 Introduction

This chapter describes the research design and approaches used in this study. It also describes the sampling methods used and data collection instruments. Lastly, the tools for data analysis are presented and limitations identified.

3.2 Overall Research Question

“To what extent have *human resource* and the current *electricity tariffs* influenced the service provider’s *operations and maintenance* activities in improving the *quality of electricity supply* in Lusaka, Zambia”?

3.2.1 Specific Research Questions

- a. *What factors of human resource influence operations and maintenance activities?*
- b. *To what extent do the current tariffs meet operations and maintenance costs?*
- c. *What are the critical factors of operations and maintenance and how do they influence the quality of electricity supply in Lusaka?*

3.2 Operationalization: Variables and Indicators

Definition of Concepts and Variables

3.2.1 Behavioral Theory of Organizations

This theory is premised on the work of Cyert and March (1963) based on their book entitled, “A behavioral Theory of the Firm” which recognized business organizations as “behavioral entities” and therefore drew its principles from the concept of “bounded rationality” in understanding how behavior in organizations influences decision-making in the attainment of organizational goals (Argote and Greve, 2007). The theory takes a process-oriented view in which decisions on price and output are made through the study of multiple persons and consequently multiple organizational units. This therefore forms the overarching theory used in the study of ZESCO which is the unit of analysis in this study.

3.2.2 Theory of Modern Management and Strategic Management Concept

There are many definitions of management, however many scholars agree that management can be understood in terms of coordinating activities of planning, organizing, motivating and controlling (Cole and Kelly, 2011). In the later part of the twentieth century, theorists of modern management adopted a strategic focus to organizational management. As a result strategic mission, values and organizational culture have now become some of the objectives of modern management.

According to Nag, Hambrick, Jer-Chen (2007), strategic management can be defined as dealing with “*the major intended and emergent initiatives taken by general managers on behalf of owners involving utilization of resources to enhance the performance of firms in their external environments*”.

Based on the above definition of strategic management, the main independent variables in this research being, human resource and electricity tariffs can be interpreted as being among the “resources” that are referred to in the definition of strategic management whereas “operations and maintenance” which is the intervening variable can be seen as the “performance” part of

the same definition which is affecting the dependent variable which in this case is the “quality of electricity supply”.

3.2.3 Human Resource

Human resources according to Wright, McMahan, McWilliams (1993), can be defined as “the pool of human capital under the firm’s control in a direct employment relationship”. The focus of the authors in this context was the knowledge, skills and abilities that the organization is made up of. However, for purposes of this study, human resource will be limited to the continuous training of employees directly involved in the utility’s operation and maintenance activities and their optimal numbers. Further, motivation as identified in the definition of management will also be taken into consideration as one of the important factors that could influence the utility’s operations and maintenance activities.

3.2.4 Electricity Tariffs

The service provider’s current electricity tariffs are an important factor that influences operations and maintenance. The National Electric Energy Agency of Brazil (2008) defines an electricity tariff as “*the composition of evaluated costs which represents each part of the investments and technical operations performed by the chain of production agents and the structure necessary for the energy to be consumed by the customer*”. This study will therefore seek to determine the sufficiency of the current tariffs in meeting operations and maintenance costs which in the definition above are referred to as “technical operations”.

3.2.5 Operations and Maintenance

According to Sullivan, Pugh, Melendez, and Hunt (2010) “*Operations and Maintenance are the decisions and actions regarding the control and upkeep of property and equipment. These are inclusive but not limited to the following; actions focused on scheduling, procedures, and work/systems control and optimization; and performance of routine, preventive, predictive, scheduled and unscheduled actions aimed at preventing equipment failure or decline with the goal of increasing efficiency, reliability and safety*”. From the text in the above definition, it can be seen that there are a number of management, operational and maintenance activities that are essential in ensuring that the service is delivered reliably and safely. The research therefore sought to explain how the service provider’s Operations and Maintenance activities influence the quality of electricity supply.

3.2.6 Quality of Electricity Supply

Holt (2005) describes the quality of service supplied by a utility to be *the delivery of services to consumers including activities preceding and following service delivery including network components (hardware and software) through which the service is provided*.

3.3 Measurement of Variables (Indicators)

The main variables derived from theory and concepts used in this study are shown in Table 2 together with their corresponding indicators.

3.3.1 Human Resource

The following are the indicators identified in the literature reviewed on human resource:

- *Continuous training & development* - According to Dhar (2015) and also Tech-Hong and Yong-Kean (2012) is directly correlated with organizational performance.
- *Customer/employee ratio* – Based on Kapika and Eberhard (2013) this ratio measures operational efficiency and productivity.
- *Factors Influencing Staff costs* – According to Levy and Palale (2014), staff costs have a bearing on the financial performance of an organization.

- *Performance management system* – According to Itika (2011) involves the setting of performance criteria, performance assessment and rewarding deserving employees accordingly. He further argues that it is difficult to know whether a department is achieving its objectives in the absence of performance assessment.

3.3.2 Electricity Tariffs

To measure the current electricity tariffs and how they influence operations and maintenance, the following indicators were identified from the literature review:

- *Effective tariff/cost per kWh ratio* – This is drawn from the work of Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), who studied the measurement of performance of Sub-Saharan African utilities.
- *Operating costs to revenue billed* – This is another indicator used to determine whether operating expenses are covered by revenue according to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009).
- *Barriers to attaining Cost reflective tariffs* – This is an indicator that this study will seek to explore, to help provide recommendations to address the problem of persistent below cost tariffs as stated by Levy and Palale (2014) and Kapika and Eberhard (2013).

3.3.3 Operations and Maintenance

There are a number of factors that can affect operations and maintenance but the scope of this study has limited itself to aspects of human resource and the current electricity tariffs as among the most important factors. Consequently, only a few indicators of operations and maintenance will be used for measurement.

- *Type of maintenance strategy* – There are a number of strategies adopted by utilities based on costs and importance of the components making up the assets. These strategies have been highlighted by Schneider, Gaul, Neumann, Hografer, et al. (2006) and Abu-Elanien and Salama (2009).
- *System losses* – According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) and Eberhard, Rosnes, Shkaratan, and Vennemo (2011) this is an important factor in measuring losses in the transmission and distribution system which reflects on the operation and maintenance of the organization
- *Load Factor* – This determines the equipment usage efficiency based on the peak demand. However it may also indicate whether the network is nearing its capacity limit and is at risk of collapsing (Tallapragada, Shkaratan, et al., 2009)
- *Available O&M Plans* – This indicator was chosen in line with the Institute of Asset Management's PAS 55-1:2008 framework for asset management which identifies asset management plans as part of the non-structural assets of the organization.

3.3.4 Quality of Electricity Supply

The quality of service based on the literature refers to the technical and commercial services offered to consumers by the utility. This study focuses on the technical standards related to reliability. As such the quality of electricity supply with regards to the number and duration of power interruptions is a key performance measure of reliability. Based on the work of Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), the most measured indices under reliability are:

- ***The System Average Interruption Frequency Index (SAIFI)***. This is the ratio of: *Total customer interruptions/Total customers served*.

➤ **The System Average Interruption Duration Index (SAIDI).** This is the ratio of:
Total customer hours of interruptions/Total customers served.

➤ **The Customer Average Interruption Duration Index (CAIDI).** This is the ratio of:
Total customer hours of interruptions/Total customer interruptions.

The above indices are used to measure the number and duration of service interruptions. Therefore, the outcome of this research should be to determine how the above indices are being affected by the service providers operations and maintenance activities. Table 2 gives an overview of the indicators to be measured in this research.

Table 2: Overview of research questions

Research Questions	Variables	Indicators	Questions	Analysis
a. What factors of human resource influence operation and maintenance activities?	Human Resource	✓ Policy on training & Continuous development ✓ Customer/employee ratio ✓ Staff Performance Management System in place ✓ Factors influencing staff costs	Refer to annex 1- Case study protocol log file	Qualitative and descriptive
b. To what extent do the current tariffs meet operations and maintenance costs?	Current Electricity Tariffs	✓ Actual O&M costs vs approved budget ✓ Effective tariff/cost per kWh ratio ✓ Cost reflective tariff barriers	Refer to annex 1- Case study protocol log file	Qualitative and descriptive
c. What are the critical factors of operations and maintenance and how do they influence the quality of electricity supply in Lusaka?	Operations & Maintenance	✓ Available O&M Plans ✓ Type of Maintenance strategy ✓ System Losses	Refer to annex 1- Case study protocol log file	Factual and descriptive
	Quality of Supply	✓ The System Average Interruption Frequency Index (SAIFI) ✓ The System Average Interruption Duration Index (SAIDI) ✓ The Customer Average Interruption Duration Index (CAIDI)	Refer to annex 1- Case study protocol log file	Factual and descriptive

3.4 Research Type and Strategy

The objective of this research was to explain the effect of human resource and the current electricity tariffs on ZESCOs operations and maintenance activities and how this affects the quality of electricity supply in Lusaka, Zambia. This led to the formulation of the main research question which according to Thiel (2007) must have a direct relationship with the research aim meaning that the two should correspond. Further, the type of research is determined by its position in the empirical cycle of scientific research which demonstrates that inductive research is conducted where there is little existing knowledge on the subject or where there is sufficient existing knowledge in the case of deductive research which seeks to explain the research problem using existing theories (Thiel-van, 2007). In this regard, the type of research of this study is explanatory as there is a considerable amount of existing knowledge on organizational behavior including the variables being studied as was found during the literature review.

This being an explanatory type of research, therefore required a qualitative data collection approach in order to get an in-depth understanding of the causal link between the two independent variables; the intervening variable and; and the dependent variable identified in the main research question. In view of the foregoing, the best suited research strategy selected for this study was found to be the single holistic case study strategy. According to Thiel (2007)

case study research is normally conducted in a real-life setting and applied in public administration on topics of a unique or rare phenomenon (Thiel-van, 2007). However, Thiel (2007) also argues that case study research can also be applied to cases that are more common place and that it is possible to consciously choose a single case to study on the premise that it constitutes an extreme example.

In this context, ZESCOs performance in terms of operations and maintenance is said to have deteriorated due to underinvestment in its infrastructure owing to extremely low tariffs and staff challenges among others leading to unprecedeted blackouts that were unheard of in the past but have now become a common phenomenon (Kapika and Eberhard, 2013). Although not unique per se, ZESCO can be said to constitute an extreme case in comparison with other utilities within the SADC region. This is because ZESCO has the lowest tariffs within the region at \$0.06/KWh arguably because of its historical background where electricity was once upon a time in abundance due to a flat demand. In fact Zambia, in the late 1980s had the lowest tariffs in the world at \$0.03/KWh leaving no expenditure for investments to develop new power generation projects and similarly underinvestment in operations and maintenance. These electricity dynamics were radically transformed in the 2000s as the country experienced a near fivefold increase in the price of copper which is Zambia's mono-export, triggering accelerated economic growth and increased electricity demand (Levy and Palale, 2014).

3.5 Data Collection Methods and Sampling

“No matter how small our sample or what our interest, we have always tried to go into organizations with a well – defined focus – to collect specific kinds of data systematically.”
Mintzberg, 1979.

3.5.1 Study area

The study was conducted in Lusaka which is the capital city of Zambia and constitutes 40 percent of the total electricity produced. Lusaka's distribution network is divided into four regions (East, West, Central and South) which together constitute ZESCO Lusaka division.

3.5.2 Unit of Analysis

The unit of analysis in this research is ZESCO which is the electricity supply service provider. As such, interviews were conducted with respondents within ZESCO. However, for purposes of triangulation and in order to increase validity, interviews were also conducted with respondents from the Regulator (ERB), Ministry of Energy and Water Development (MEWD), Kafue Gorge Regional Training Centre (KGRTC) and one respondent who happened to be a former Managing Director of ZESCO.

3.5.3 Secondary Data

Secondary data in the form of published and unpublished materials was collected through desk research mainly from internet sources and were used to inform the state of the art on the subject under study. During the field work, additional secondary data was collected to assist in answering the specific research questions. This data was mainly collected from the sector regulator (ERB).

3.5.4 Primary Data

Qualitative data was collected using a semi-structured interview manual as the main data collection instrument. The manual contained an introduction, the actual questions and a concluding section (See Annex 1 – Case Study Protocol Log File). This was administered to respondents within ZESCO and also to the regulator, the Ministry of Energy and Water Development, Kafue Gorge Regional Training Centre and a former Managing Director of ZESCO. The selection of other experts within the sector was done in order to increase validity of the research findings.

The semi-structured interview manual was prepared prior to the field work and approved by the research supervisor. This facilitated the measurement of indicators on the four variables namely; human resource; current electricity tariffs; operations and maintenance and; the quality of electricity supply. Permission to record the interviews was sought from almost all the respondents in order to increase accuracy during the transcription process following the fieldwork. Further, a member check (respondent validation) was conducted to ensure that the content of the transcripts was accurately interpreted (See Annex 5 for sample of respondent validation email).

3.6 Sample Size and Selection

The sample size for this research was based on an estimate of the population (N) within ZESCOs Lusaka Division including the directorates of Human Resource, Finance, and Distribution & Supply based at head office within Lusaka. Lusaka Division is comprised of four regions namely; Lusaka East; Lusaka West; Lusaka South and Lusaka Central. However due to limited time available for this study, only two regions (Lusaka Central and Lusaka East) were considered in the sampling. The rationale behind choosing Lusaka-Central and East was based on the fact that Central region manages in part the busy Central Business District which has been expanding at a fast rate due to rezoning of residential areas. Further, Lusaka has also been growing eastwards towards the city's international airport and beyond. This makes these two regions strategically important for this study.

Based on the above considerations, the estimated research population (N) was estimated to be around 90 members of staff from which by using a non-probabilistic, purposive sampling approach, 20 respondents were initially intended to be interviewed. In order to ensure representation from all levels and to increase accuracy of the results, selection of respondents was made using a stratified approach according to the different layers of the organization. Using this criteria respondents were drawn from top management, senior management and middle management. Table 3 shows the list of respondents purposively selected prior to commencement of the field work.

Table 3: Initial sample size and distribution

	Position	Department	Hierarchy	No.
ZESCO				
1	Director – Human Resource	Human resource & Admin	Top management	1
2	Senior Manager – HR & Training	Human resource & Admin	Senior management	2
3	Director - Finance	Finance	Top management	1
4	Finance Manager	Finance	Senior management	1
5	Director – Distribution & Supply	Distribution	Top management	1
6	Divisional Manager (Lusaka)	Distribution	Senior management	1
7	Regional Control Centre Manager	Distribution	Middle management	1
8	Regional Managers (East & Central)	Distribution	Middle management	2
9	O&M Engineers (East & Central)	Distribution	Operations	4
10	O&M Technicians (East & Central)	Distribution	Operations	2
ERB				
11	HER - Electricity	Electricity	Senior management	2
MEWD				
12	Planner	Energy Planning Unit	Middle management	1
PMRC				
13	Policy Analyst	Research	Middle management	1
Total Sample (n)				20

However, during the fieldwork which was conducted between 22nd June 2015 and 14th July 2015, amendments were made to the initial sample of respondents based on advice from initial points of contact. For example, it was found that lower echelon technical employees would not be familiar with the scope and complexity of the study. This resulted in a reduction in the initially intended sample size. Also, recommendations were made to include other respondents who were deemed to be better placed and familiar with the subject being researched. Based on these recommendations, the sample was revised and a total of 11 members of staff within the utility were interviewed. In addition, 3 external respondents were interviewed from organizations deemed to be relevant to the research. In addition, one respondent was selected based on their wealth of experience having previously worked at ZESCO as Managing Director. The final sample size (n) therefore consisted of 15 respondents. As observed by Thiel (2007), there are no firm rules guiding the ideal size of a non-probability sample suffice to say that the larger the sample the better. The downsizing in this case was inconsequential to the outcome of the research as the respondents excluded did not materially affect the objective of case study research which was to get in-depth understanding and not to produce summery statistics. Freedom to make adjustments is a key feature in theory-building case study research if such an alteration is likely to yield better results (Eisenhardt, 1989). The exclusion of certain respondents allowed more time to be dedicated to key respondents. Table 4 shows the sample size and distribution of respondents interviewed. (See Annex 1 – Case study log file for full description of changes).

Table 4: Final sample size and distribution

	Position	Department	Hierarchy	No.
ZESCO				
1	Director – Finance	Finance	Top management	1
2	Director – Distribution & Supply	Distribution & Supply	Top management	1
3	Senior Manager - Senior Manager – Budgets & Investments	Finance	Senior management	1
4	Senior Manager – HR Development	HR & Admin	Senior management	1
5	Senior Manager – Business Dev.	Business Development	Senior management	1
6	Divisional Manager (Lusaka)	Distribution & Supply	Senior management	1
7	Manager – HR - Planning	HR - Planning	Middle management	1
8	Regional Manager – Lusaka East	Distribution & Supply	Middle management	1
9	Regional Manager – Lusaka Central	Distribution & Supply	Middle management	1
10	Principal Engineer – Lusaka East	Distribution & Supply	Middle management	1
11	Principal Engineer – Lusaka West	Distribution & Supply	Middle management	1
ERB				
12	Senior Manager – Tech. Regulation	Electricity	Senior management	1
MEWD				
13	Asst. Director-Electricity Power Development.	Energy Planning Unit	Senior management	1
KGRTC				
14	Training Manager	Training	Middle management	1
Independent Expert				
15	Former Managing Director		Retired	
Total Sample (n)				15

3.7 Validity and Reliability

3.7.1 Validity

i. Internal Validity

Internal validity refers to whether the study measures what was intended (Thiel-van, 2007). In order to increase internal validity, the data collection instrument had to adequately operationalize the variables into clearly defined and measurable indicators. Further, to ensure that this was adequately done, indicators were benchmarked with internationally used criteria in accordance with the ones specified by Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) for electricity utilities in developing countries. The findings were in turn compared with secondary data on performance of electricity utilities in the Southern African Development Community (SADC) obtained from the regulator. In addition, the interviews with external experts in the electricity sector contributed in triangulating data obtained from ZESCO.

ii. External Validity

According to Thiel (2007), external validity is the extent to which findings of a study can be generalized viz a viz whether the results hold for other persons, institutions, locations and so on which is particularly important for statistical research. However, the use of the single case study research strategy makes it difficult to generalize findings due to the small sample population that characterises qualitative research as many scholars have observed. As such, the findings of a single case are only valid for the case in point. However, as argued by Thiel (2007), it is almost always possible to relate single cases to higher abstraction levels of domain to which the case belongs. It is therefore often possible that findings can be regarded as representative of similar situations within the same research domain (Thiel-van, 2007). Yin (2003) also argues that case studies are generalizable not to populations but theoretical propositions. The aim in case study research is to expand and generalize theories and not to enumerate frequencies (Yin, 2003). Similarly, the theoretical knowledge gained from the findings of this research would therefore be generalizable to service providers of a similar make-up to ZESCO including water utilities.

3.7.2 Reliability

Reliability according to Black (2002) refers to the degree of consistency that two or more instruments measure the same thing. This is often difficult to achieve when using an open research design such as the case study where interviews may differ slightly from one to the next. In order to ensure reliability, this study maintained a logbook which documented all the steps taken in the study including changes to initial propositions (See Annex 1 – Case Study Protocol Log File). In addition, the case study protocol was used as a systematic guide in the data process during fieldwork. All changes in the semi structured interview manual were documented in the logbook and reflected in the case study protocol.

3.8 Data Analysis Methods

The primary data collected using semi-structured interviews during fieldwork was transcribed and validated through a member check with the respective respondents. Using Atlas Ti version: 7.5.7, the interviews were coded according to the variables in the operationalization. The codes /labels were used to assign quotations given by each respondent. Outputs were then generated for each code and compared. Further, comparisons were made between the responses from ZESCO and external experts by creating families and generating outputs. Quotations were then analysed based on the researcher's interpretation and frequency. Uncommon but significant quotations were also analysed and judgement made to include them in the findings. Secondary data sources were used to corroborate the findings from interviews.

Finally, the findings were presented using tables, figures and graphs.

3.9 Limitations of the study

Written permission had to be sought to conduct research with the service provider which process took some time, thereby reducing the time available for the research (See Annex 2 and Annex 3 – Letter of Introduction and Letter of Authority to conduct research). Also, the field work was conducted at a time when the country was facing a critical electricity shortage as water levels in the reservoirs were said to be low due to poor rainfall during the past season. This affected the schedule of appointments as most of the targeted respondents were busy attending to the crisis. This resulted in some of the intended respondents not being interviewed as they were reported out of office.

As ZESCO Lusaka Division is divided into regions, the data collection exercise proved to be difficult considering that the regional offices, head office and Lusaka division office itself are all situated in different locations which presented a number of logistical challenges. This also resulted in loss of time with regards to travelling and waiting time between offices.

Lastly, it was difficult to access some of the primary data as most of it was not readily available and required time to be compiled.

Chapter 4: Research Findings

4.1 Introduction

This chapter presents the research findings of the fieldwork described in the previous chapter. An overview of the research case is given, describing the unit of analysis and a brief background of the problem. The findings from the data collected during the fieldwork are arranged according to the main variables identified during the operationalization and the indicators that were developed in order to answer the main research question. Data is analysed by arranging responses obtained during interviews according to codes developed using Atlas Ti software. Finally the findings are summarized using frequency tables and discussed according to the theoretical review and conceptual framework in chapter 2. Secondary data collected during fieldwork is also used to analyse the findings for consistency or variances.

4.1.1 Description of the Case

This research was based on a single holistic case study of the electricity service provider (ZESCO) which is vertically integrated at generation, transmission and distribution. The service provider therefore operates as a natural monopoly and is wholly owned by Government but operates under private sector law since its commercialization. However, its performance has come under scrutiny in the last 5 to 10 years as there has been increased load-shedding which it largely attributes to inadequate generation capacity. Further, customers experience unplanned outages as a result of bottlenecks in the distribution network due to ageing infrastructure. This situation has been compounded by electricity tariffs which are said to be among the lowest in the region coupled with high staff costs affecting the available revenue for operations and maintenance resulting in the deterioration in the quality of electricity supplied to consumers.

4.1.2 Sample

The sample for this research was drawn purposively using a non-probability sampling criteria from members who were identified as being knowledgeable about the research topic based on their position within and outside the service provider. To ensure representativeness, the respondents were selected using a stratified approach from the different layers within the organization. As such, there was representation from top, senior and middle management contributing 11 respondents to the total sample size. In addition, 4 more respondents were selected from the Energy Regulation Board; Ministry of Energy and Water Development; Kafue Gorge Regional Training Centre and; one former Managing Director of ZESCO making a total sample size of 15 respondents.

4.1.3 Data presentation and analysis

The qualitative data collected using interviews is presented according to the sub-research questions stated in the previous chapter. Using Atlas Ti, outputs are generated from codes specific to each sub research question and quotations analysed and summarized in table format noting the frequency of each response based on the sample size. Human resource; the current electricity tariffs; operations and maintenance and; the quality of electricity supply therefore form the themes by which findings are presented. Furthermore, secondary data collected during the study is used to support findings for purposes of validity where available.

Finally a narrative of the findings is given noting the importance of the findings and whether the findings were expected or not and if at all they are consistent with the literature reviewed in Chapter 2. Lastly, a summary of the most important findings is given at the end of each section.

4.2 Human resource factors that influence Operations and Maintenance

This section analyses findings related to human resource which influence operations and maintenance. Specific questions on opinions; adequacy; training; staff performance; staff costs and; opinions on important factors of human resource where asked to respondents and responses are summarized in table 5.

Table 5: Human resource questions and summary responses frequency table

	Question	Summary of responses	Frequency
1	Opinion on importance of human resources to O&M activities	✓ Human resource is critical as without manpower it would not be possible to carry out O&M.	10
		✓ Human resource continues to be important to O&M despite the advent of computerised systems.	3
		✓ Distribution is the largest directorate and therefore the main customer interface of the utility.	2
2	Adequacy of O&M staff in relation to customers served in the regions.	✓ O&M staff was found to be inadequate in relation to the customers served within the regions. [6] ✓ The regions were serving twice the required customer/employee ratio of 100:1 as required by the regulator. [4]	10
		✓ The numbers of O&M staff are adequate based on the customer/employee ratio set by the regulator. [2] ✓ ZESCO is currently not doing well on its customer/employee ratio (87:1) as it is measured at corporate level and not divisional level. There is an imbalance between support and O&M staff. [3]	5
3	Policy on training and continuous development.	✓ ZESCO has a training policy which supports both short and long term courses at various levels based on available resources. ✓ Short term courses for linesmen and cable jointers are conducted in-house at the ZESCO training school in Ndola. [6] ✓ The utility trains over 200 employees in various disciplines in a year and this is a continuous cycle. For example there were 70 technical staff undergoing training in the current financial year.	15
4	Staff performance management system	✓ The current staff performance management system is ineffective and the utility is in the process of introducing the Balanced Score Card.	12
		✓ The utility has a performance management system in place which is used to evaluate individual performance through an appraisal system.	3
5	Factors influencing ZESCO's staff costs	✓ Staff numbers are relatively higher in support functions than in O&M. ✓ Staff costs are seen as high as they are a ratio of the revenue which is insufficient due to depressed tariffs. ✓ O&M staff tend to work overtime as faults can occur anytime including weekends. ✓ The type of technology being used is basic and requires a lot of manpower for example, replacing wooden poles.	5 4 5 1

6	Opinion on Important factors of human resource that influence O&M activities.	<ul style="list-style-type: none"> ✓ <i>Training:</i> Staff should be trained in the right skills including multi-skilling. ✓ <i>Attitude:</i> A positive attitude is important as the business involves interaction with customers. ✓ <i>Motivation:</i> Proper rewards system based on performance. ✓ <i>Numbers:</i> Adequate numbers of O&M staff 	12 8 6 5
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i. *Opinion on importance of human resources to O&M activities*

As can be seen from table 5 above 10/15 respondents considered human resource to be very important as without manpower it would not be possible to carry out operations and maintenance. This is valid regardless of the introduction of modern systems and tools that still require human intelligence to be operated as was pointed out by 3 respondents. Further, 2 respondents described distribution and supply as the largest directorate which serves as the customer interface of the utility and hence the importance of human resource to operations and maintenance. These results are expected as shown by the Institute of Asset Management's PAS 55-1:2008 framework in figure 1, chapter 2 which demonstrates that the successful management of physical assets goes beyond just technical activities to include non-structural assets such as human assets.

ii. *Adequacy of O&M staff in relation to customers served in the regions*

In terms of adequacy of staff, 10/15 respondents indicated that operations and maintenance staff were inadequate in comparison with customers served within the regions. According to 4/15 respondents, the customer/employee ratio stipulated by the regulator was 100:1 whereas the regions where serving twice (200:1) this ratio. However, according to respondent - R4 "the problem was that the customer/employee ratio was configured at a corporate level" and as such it seemed there were more staff in support functions than in operations and maintenance. Respondent – R5 however stated that Lusaka had the highest customer base and hence was twice above the set customer/employee ratio of 100:1 but that the ratio for the whole utility was almost within the target set by the regulator.

External respondent - R6 noted that as much as the target for ZESCOs customer/employee ratio was set at 100:1, the utility was not meeting it as their ratio was currently at 87:1. He further indicated that this target was set at corporate level and that it would be expected that the utility would hire more operations and maintenance staff but this was not the case. These results were not expected as the literature reviewed indicates that ZESCOs customer/employee ratio is currently at 87:1 which gives an impression that there are more than adequate staff in relation to the customers served and yet under distribution and supply there are fewer staff serving more customers than stipulated by the regulator. The low customer/employee ratio suggests that there are large numbers which not only result in increased average labour costs but also affect overall productivity and efficiency (IPA Energy Consulting, 2007).

iii. *Policy on training and continuous development*

Based on the literature reviewed for this study, an explicit policy on training and development shows how organizations are committed to maximizing their employees' potential (Itika, 2011). Accordingly, all 15 respondents indicated that ZESCO had a policy for training and continuous development for its staff. Six (6) respondents highlighted various categories of training including; short-term training; long-term training and; capacity building. ZESCO has a training centre situated in Ndola which offers short-term training programmes mainly for skilled staff such as Cable Jointers and Linesmen who are at the centre of handling faults. The

Kafue Gorge Regional Training Centre also offers short courses related to hydro power production.

In addition to short courses, ZESCO also offers support for long-term training for advancement of its employees at diploma, technologist, degree and masters level both on full-time and part-time basis. In addition, there are capacity building programmes which cut across all levels of management.

In terms of numbers of staff attending training, the number was dependent on the availability of funds but the utility tries to sponsor as many people as possible and that this was a continuous cycle which usually spills into the following financial year. However, according to respondent – R11, the main focus was on technical staff as this was the core business of the utility. In a year, the utility trains roughly 200 staff at the ZESCO training centre which offers purely technical courses. “Currently we have about 70 technical employees pursuing training on a full time basis at various levels within the current financial year, of which 28 are doing electrical engineering” said the respondent – R11.

These results are expected in that going by the nature of business, ZESCO is expected to have adequately trained technical staff to effectively manage its operations and maintenance activities. The findings are also consistent with Esmaili (2012) cited in Chapter 2 who states that asset management staff must be adequately trained to ensure that they are kept up to date with their competencies as required by their role. This also confirms that organizations now view human resources as assets which if invested in can generate revenue and profit as argued by Liu, Combs, Ketchen and Ireland (2007) in chapter 2.

iv. Staff performance management system

12/15 respondents stated that the utility had a performance management system in place but that it was ineffective and that the utility was in the process of introducing the Balanced Score Card system for performance evaluation. According to respondent - R4, the current performance management system lacked objectivity and there was no consistency in assessing performance. As such, what was there currently was just a thirteenth cheque. However, according to respondents, R5 and R9 despite there being a weak organizational performance management system, Distribution and Supply had devised their own performance score card where regions were made to compete in terms of resolution of faults and maintenance even though this was not formalized.

Meanwhile 3/11 respondents indicated that the utility had a performance appraisal system where each individual was supposed to sign a performance agreement with their supervisor based upon which performance would be evaluated. However, they were unsure whether this was being followed.

As Itika (2011) has stated in chapter 2, performance assessment is important in determining whether or not a department or section is achieving its objectives as this forms the basis for acquiring the right skills, numbers and incentive based rewards (Itika, 2011). According to behavioural theory, organizations are adaptive systems which are capability-centered and solve problems by relying on shortcuts, routines and standard operating procedures. However, according to Dosi and Marengo (2007), the antecedent of this *problem-solving* view of behavioural theory is the *incentive view* which censors the competence aspect of how organizations conduct business. The problem-solving view assumes that all employees are willing to cooperate in order to attain common organizational goals (Dosi and Marengo, 2007).

On the other hand the findings revealed how as a unit, distribution and supply had devised their own performance management system which though not formalized had invoked competition among regions for better performance. This is consistent with behavioural theory which sees

firms as possessing competencies of problem-solving within operating procedures and routines which in turn become enshrined in the patterns of the internal organizational division of labour (Dosi and Marengo, 2007). The informal performance management system adopted by the distribution and supply has likely influenced the entire organization to devise an effective performance management system.

These findings would be expected based on the historical perspective of Sub-Saharan utilities which according to Lesueur and Plane (1994) in the past simply used to raise wages uniformly across the board before introduction of the structural adjustment programme, during which the World Bank recommended the introduction of performance oriented pay systems.

Furthermore, it is therefore plausible that ZESCO is making an effort to implement these reforms which are now common practice for commercial business entities.

v. *Factors influencing ZESCO's staff costs*

According to recent reports by the Energy Regulation Board, ZESCO's staff costs were said to be high, averaging above 50 percent of its annual turnover. Almost all respondents interviewed acknowledged this fact with various opinions on the drivers of staff costs. 5/15 respondents stated that the high costs were mostly driven by the *staff numbers* which were arguably higher in support functions. One respondent in senior management argued that there were more numbers in support functions and estimated that over 2,000 new people had been employed over the last two years.

3/15 respondents however attributed the large numbers to casual workers (temporary workers) that the utility normally hired due to the nature of operations and maintenance works which required a lot of manpower. Respondent – R10 for example had noted that Lusaka-Central region had recorded an increase in casual workers from 150 to about 200 in two years. Respondent – R9 also confirmed that the utility used to hire casual employees in the past but had since stopped. These findings are consistent with Levy and Palale (2014) whose findings were that the utility's wage bill continued to be high even after its commercialization amounting to over 50 percent of its annual income. The utility's staff numbers had previously risen from 4,000 in 2002 to 5,000 in 2006 (Levy and Palale, 2014).

4/15 respondents attributed the high staff costs as a ratio of the current revenue that the utility was earning which was insufficient owing to *depressed tariffs*. According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), a survey conducted among utilities in Sub-Saharan Africa revealed that most utilities had tariffs which were not covering operational costs as well as capital costs. Zambia's total cost recovery was the worst among the countries surveyed at 38 percent.

Staff costs were also said to be driven to a certain extent by *overtime*. 5/15 respondents indicated that overtime was a driver of staff costs due to the nature of the business arguing that faults on the network could occur at any time including weekends which attracted overtime for operations staff. According to respondent - R7 the inadequacy of operations and maintenance staff in terms of numbers required them to work overtime in order to cope with the workload. Furthermore, it was found that regions such as Lusaka-Central also covered the Central Business District where it was difficult to undertake maintenance works during normal business hours during the week thereby requiring them to work over weekends.

Lastly, the level of technology currently being used by the utility was said to be basic and not mechanized and as such was labour intensive. In this regard, respondent – R10 gave an example of the need to continuously replace wooden poles which required about 14 casual workers to lift a single wooden pole whereas if the utility was using concrete poles, this could be a one off operation as there would be no need for constant replacement.

vi. *Important factors of Human Resource that influence Operations and Maintenance activities.*

Respondents were asked to give their opinions on what they thought were the important factors of human resource that had a direct influence on operations and maintenance activities. The following factors were found to be common among the respondents interviewed:

- a. *Training* – 12/15 respondents regarded training to be extremely important as operations and maintenance staff were required to have adequate training in the right skills including multi-skilling as demanded by modern business practices. This result is expected as has been discussed under item (iii) above.
- b. *Attitude* – Although this was not in the initial inquest as an indicator, 8/15 respondents observed that positive attitude was very important for operations and maintenance staff as these were the interface between the utility and the customer. Respondent – R4 referred to a need for behavioural change which the utility was trying to pursue through training programmes such as ‘change management’. This could also be seen through observations made during the field work.
- c. *Motivation*: 6/15 respondents indicated that motivation played a big role in the performance of operations and maintenance staff. For example one middle management respondent observed that the absence of a proper rewards system such as promotion criteria negatively affected employee performance. Another respondent cited overtime as one of the benefits that motivated operations and maintenance staff but that the utility had since clamped overtime at 50 hours per employee beyond which employees were reluctant to attend to emergencies.

According to the IPA Energy Consulting report of 2007, ZESCO’s average employee earned 64 times the country’s GDP per capita compared to South Africa’s ESKOM for example whose average employee earned 9.5 times that country’s GDP per capita. This suggests that the ZESCO average employee is well remunerated in comparison to other utilities within the SADC region. This can be corroborated with Respondent – R11, who confirmed that the utility offers competitive salaries and as such labour turnover was low. 3 of the 6 respondents who mentioned motivation as an important factor, stated aspects of progression and training opportunities as motivational factors for employees.

- d. *Numbers* – in terms of staff numbers, 5/15 respondents highlighted the importance of having adequate numbers for efficient operations and maintenance. As the findings on the customer/employee ratio have suggested, there seem to be more staff employed in support functions than in operations and maintenance. According to the RERA (2015), the customer/employee ratio is a key efficiency and productivity indicator used to measure utilities’ performance around the world. As such, too high a ratio may suggest that the utility is not servicing its customers adequately, where too low a ratio may indicate inefficiencies in the way the utility is managed (Regional Electricity Regulators Association of Southern Africa, 2015).

In summary, the main factors of human resource found to be influencing operations and maintenance were the *customer/employee ratio at divisional level*, where there were inadequate staff dedicated to operations and maintenance. Also, the absence of an effective staff *performance management system* affected employee motivation as there was no clear criteria for promotions, nomination for training and bonus rewards. Finally, the *attitude* of employees towards work was also seen as a factor that influenced operations and maintenance activities.

4.3 Current electricity tariffs

This section analyses the adequacy of the current electricity tariffs and their influence on operations and maintenance. Opinions and factual data was therefore obtained from

respondents on sufficiency; budget adequacy and; cost reflectivity. Respondents were further asked to give their opinions on what they thought were the barriers being faced by the utility in attaining cost reflective tariffs as it was felt that this data would be useful in making recommendations and perhaps formulating future research topics. Table 6 shows a summary of responses obtained and their relative frequencies.

Table 6: Current electricity tariffs questions and summary responses frequency table

	Question	Summary of responses	Frequency
7	Opinion on sufficiency of current tariffs in meeting O&M costs.	<ul style="list-style-type: none"> ✓ The current tariffs are insufficient and do not fully cover operations & maintenance costs. For example there are now independent power producers who will be selling power to ZESCO at about US\$ 0.14/KWh and yet ZESCO sells its power at US\$ 0.06/KWh. ✓ Tariffs are not cost reflective as was found by the 2007 cost of service report. The cost of service report had prescribed a course of migration to cost reflectivity but this has not been achieved. ✓ The current tariffs are just adequate based on the technology being used by the utility. However, as the technology is being upgraded, the current tariffs will be insufficient. 	14 4 1
8	Adequacy of the budget in meeting Operations and Maintenance costs.	<ul style="list-style-type: none"> ✓ Operational expenditure for O&M costs is usually covered by the budget despite the low tariffs. [9] ✓ However, there is underutilization of the O&M budget due to delays in the procurement process such as approval from the Attorney General's office. [5] Only about 60% to 70% is utilized. For example Lusaka – Central region only utilized 50 percent of the budget in 2014. ✓ O&M activities are not adequately covered by the budget as can be seen from the poor maintenance on the ground. [2] 	9 3
9	Ratio of the effective tariff against the cost of production.	<ul style="list-style-type: none"> ✓ Based on estimates, the cost of producing electricity from a new power plant is not less than US\$ 0.10/KWh. As such, the average tariff should be at least US\$ 0.10/KWh and not the current US\$ 0.06/KWh. [3] ✓ The true cost of production should therefore be based on the new power plants and not the old ones as they are sunk costs. [2] 	3
10	Barriers to cost reflective tariffs	<ul style="list-style-type: none"> ✓ <i>Mode of tariff adjustment</i> – the utility has to apply to the regulator for tariff adjustment which is a bureaucratic process as there are so many stakeholders involved. ✓ <i>Government socio-economic considerations</i> – ZESCO being a parastatal is owned and controlled by the government of the day which looks at its peoples interests by subsidizing them in one way or another. ✓ <i>Mines bulk agreement</i> – The mines consume about 60% of the power produced and signed a bulk supply agreement with government almost 20 years ago which unfortunately did not have clauses for tariff adjustment. 	9 10 3

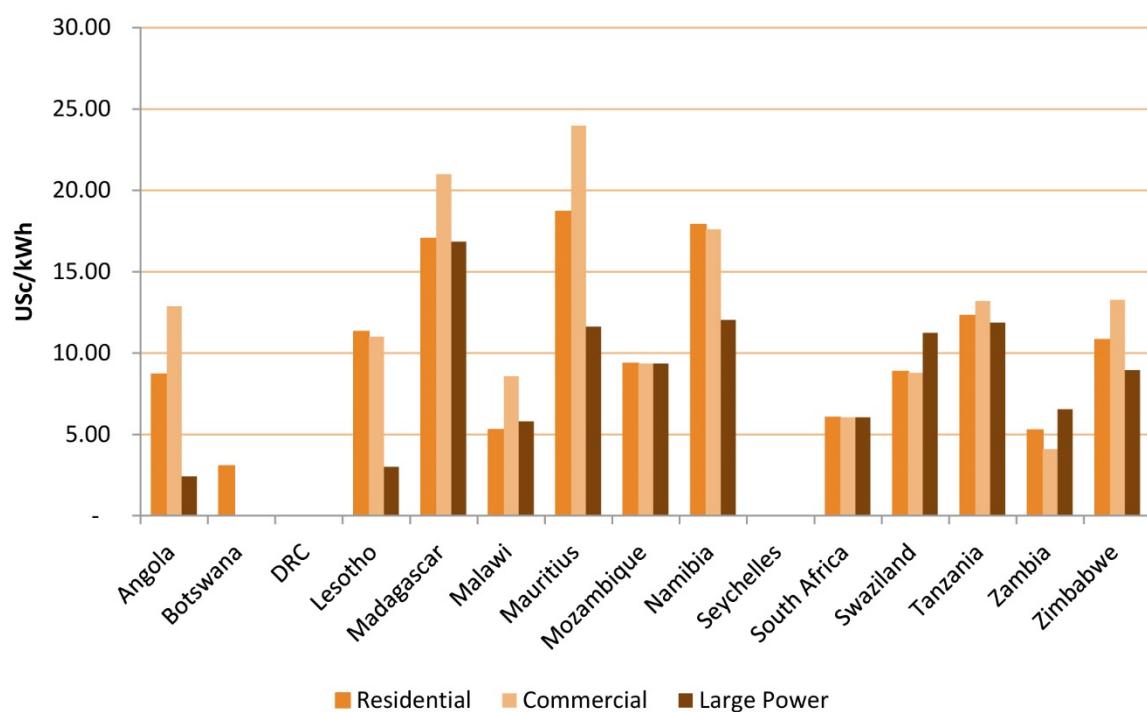
		✓ Willingness to pay – People are not willing to pay cost reflective tariffs partly because historically, electricity was very cheap (almost free).	8
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i. *Opinions on sufficiency of current tariffs in meeting operations and maintenance costs.*

According to 14/15 respondents, the current tariffs are insufficient and do not fully cover operations and maintenance costs. For example, according to respondent – R4 new independent power producers such as Maamba or Itezhi Tezhi Power Company were soon to start selling power to ZESCO at around US\$0.14/KWh compared to the current US\$0.06KWh that the utility sells its power at. Further, 4 respondents cited the 2007 Cost of Service report by IPA Energy Consulting which had prescribed the migration course in order to attain cost reflective tariffs that needed to be followed by ZESCO. Based on its findings, the utility for example needed to increase residential tariffs by about 150 percent (respondent – R4). One respondent however was of the view that the current tariffs were just adequate based on the technology being used by the utility but that with the on-going upgrading of the network which would inevitably use modern technology, the tariffs would be insufficient.

Secondary data obtained to corroborate these findings suggests that ZESCOs tariffs are among the lowest among SADC countries within the region. According to the minister of Mines, Energy and Water Development – Christopher Yaluma, Zambia's electricity tariffs were very low at US\$ 0.564/KWh compared to other countries such as Uganda whose electricity tariffs were US\$ 0.16 (Zambia Daily Mail, 2015). Furthermore, secondary data on tariffs shows the average end user tariffs as at 2013 compiled by the RERA which confirms that the average tariffs for residential consumers were around US\$ 0.06/KWh as shown Figure 7.

Figure 7: Average end user tariffs – 2013



Source: Regional Regulators Association of Southern Africa (2012/1013)

ii. Adequacy of the budget in meeting Operations and Maintenance costs.

9/15 respondents indicated that operational expenditure for operations and maintenance activities was usually covered by the budget despite the tariffs being low. This was because the budgeting process was activity based suggesting that operations and maintenance activities were based on the available resources. As indicated by one respondent – R9, “the budget for operations and maintenance was drawn from the annual turnover realized from the sale of electricity but there was more that needed to be done in terms of maintenance”. 5 of the respondents further stated that there was underutilization of the operations and maintenance budget line mainly due to delays in the procurement system as procurements above a certain threshold had to be approved by the Attorney General’s office. As such only about 60% to 70% of the budget was being utilized. According to respondent – R13, Lusaka-Central region only utilized 50 percent of its budget for 2014. 3/15 respondents however indicated that operations and maintenance activities were not being adequately covered by the budget as could be seen from the poor maintenance ground as shown by the poor quality of electricity supply.

These findings are expected since the utility was not charging cost reflective tariffs as most respondents had indicated in their opinions on sufficiency of the current tariffs. This suggests that the utility was not making full cost recovery and therefore although able to cover operations and maintenance activities in its budget, not all equipment was being maintained due to resource constraints. This is supported by Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) whose findings based on a survey of Sub-Saharan African countries indicated that Zambia’s cost recovery was at 38 percent (Tallapragada, Shkaratan, et al., 2009). These findings therefore suggest that the utility may not be adequately maintaining its distribution and supply network as they could be compromising on operations and maintenance even though the budget indicates that it fully covers operational expenditure. This can be corroborated with one external respondent – R6 who argued that what was on paper was different with what was on the ground in terms of operations and maintenance which seemed to be compromised. Further, the utility’s inability to fully utilize its operations and maintenance budget due to procurement delays was affecting its ability to adequately maintain its assets.

iii. Ratio of the effective tariff against the cost of production.

Only 3/15 respondents were able to give an indication on the cost recovery ratio which is used to measure a utilities operating expenses against its revenue. According to the respondents, the cost of producing electricity should be based on new power plants and not the old power plants which are sunk costs. Estimates suggest that the cost of producing power from a new power plant is not less than US\$0.10/KWh. Currently, ZESCO is selling its power at US\$0.06/KWh which is below cost.

According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), cost recovery ratio reflects the price – cost relationship which should take care of both operational and capital costs. Levy and Palale (2014) also suggest that an efficient electricity network should be able to supply power to its consumers at a price equal to about twice the cost of generation. However, as of 2007 estimates indicated that the cost of new hydro generation to meet increased demand amounted to US\$ 0.06 – US\$ 0.07KWh representing a cost-efficiency marginal cost of supplying power to consumers of about US\$ 0.11 – US\$ 0.13/KWh. The arguments raised by the respondents that the true cost of producing power should be based on new power plant purchase agreements are therefore valid based on the literature reviewed. The findings however, suggest that the utility was not making full cost recovery to be able to meet operational and capital costs.

iv. *Barriers to cost reflective tariffs*

- *Government socio-economic considerations* – 10/15 respondents felt that ZESCO which is a parastatal is owned and controlled by the Government which looks at the people's capacity to pay and in a way subsidizes the service. Respondent – R6 attributed this to the historical background where tariffs were kept artificially low. A historical account given by Levy and Palale (2014) also attributes the current low tariffs to political leadership which found it difficult to raise tariffs to cost reflective levels in order not to irk urban residents who had gotten accustomed to paying very low tariffs.
- *Mode of tariff adjustment* – 9/15 respondents also highlighted the mode of tariff adjustment as a barrier to attaining cost reflective tariffs as it requires applications to be made to the regulator, a process which involves several stakeholder consultations making the process lengthy and bureaucratic. According to respondent – R9, the process of tariff application was tedious compared to other countries like Kenya which automatically adjusted tariffs based on increases in fuel prices; exchange rate fluctuations and; inflation. Another example given was South Africa's ESKOM which had increased its tariffs three to four times when ZESCO had only increased twice within the same period. He therefore indicated that the utility had since proposed a multi-year tariff plan where automatic adjustments could be made based on inflation and fluctuations in the exchange rate to name a few.
- *Willingness to pay* – 8/15 respondents cited people's reluctance to pay for the service based on the historical background of having cheap electricity. This is consistent with Levy and Palale (2014) who found that utilities and regulators in most countries encountered tensions in balancing the preferences of low tariffs by their consumers and the imperative need for economic tariffs for the utility. They contend that Zambians had already gotten accustomed to paying very low rates for power which at one point was US\$ 0.03 - among the lowest in the world and therefore to increase this to cost reflective tariffs was naturally a challenge. Kapika and Eberhard (2013) in their analysis also found that it would take time for ZESCO to reach cost reflectivity and acceptance by consumers based on the low tariffs from the past.
- *Mines bulk supply agreement* – According to 3/15 respondents, the mines which consume 60 percent of the power produced had signed a bulk supply agreement with the Government almost 20 years ago which to this day is still in force. The bulk supply agreement however did not contain any clauses for tariff adjustment thereby preventing the utility from increasing mining tariffs. In addition, the design of the tariff requires that the causes of the most burden on the network pay more but this is not the case thereby burdening residential and commercial consumers more. He cited Ghana as an example where the mines were compelled to draw power from the new power plants which were more reliable at a cost reflective rate. Meanwhile, the old power plants were left to service individual consumers.

In summary, the findings on whether the utility's current tariffs meet operations and maintenance costs suggest that they do not fully cover operations and maintenance costs as indicated by the opinions of the respondents. This is despite findings that the operations and maintenance budget is adequate in covering operations and maintenance activities. This is because the current tariffs are not cost reflective at US\$ 0.06/KWh as found by the study therefore suggesting that the utility may be compromising on maintaining some of its assets even though the budget seems sufficient. Further, the utility's inability to exhaust its budget on planned activities negatively affects its performance in terms of operations and maintenance.

4.4 Operations and Maintenance

As discussed in chapter 2, electricity networks degrade over time due to ageing infrastructure which affects the performance of the network making it difficult to attain performance targets (Schneider, Gaul, et al., 2006). According to Schneider (2006) the aim of asset management is therefore to optimize the utilization of the remaining life of the asset based on a stipulated reliability of the service. This section therefore presents the findings relating to ZESCOs operations and maintenance activities. A summary of the findings is given in table 7.

Table 7: Operations & Maintenance questions and summary responses frequency table

	Question	Summary of responses	Frequency
11	Opinion on ZESCOs Operations & Maintenance of the distribution network in general.	✓ There are challenges due to bottlenecks in the distribution network resulting in overloaded transformers, system losses and low voltage because of the old infrastructure.	8
		✓ The lack of availability of materials affects operations causing delays in attending to faults.	
12	Systems, tools and guidelines used to effectively manage the distribution network.	✓ There are tools in place used to manage the distribution network, such as the Business Integrated System (BIS) which comprises the Incidence Management System (IMS) to manage faults; Plant & Equipment Management System (PEMS); Design & Construction Management System; Transport Management System and; Maintenance Management System (MMS) used to generate the 52 week plan which is further divided into a weekly plan. [13] ✓ However, the above systems were only recently introduced and are not yet being fully utilized. Currently they are only being used at about 70% of their capabilities. Most systems are not well documented except for safety procedures. There are also plans to integrate some of them as currently each one is stand alone. [5] ✓ Structures to effectively manage the systems are currently being put in place as well as standardization of checklists and maintenance documentation. ✓ ZESCO has now introduced Safety Health Environment & Quality (SHEQ) as it aims for ISO certification.	13
13	Type of maintenance strategy being used to maintain the distribution network.	✓ The utility mainly uses Time Based Maintenance (TBM) strategy for routine maintenance based on the 52 week maintenance plan. For big and critical equipment such as transformers at substations, the utility uses Condition Based Maintenance (CBM) as a strategy. CBM involves checking equipment for signs of failure before it occurs for example using thermal scans to check for 'hotspots' on bulk supply	10

		<p>points. It also uses built-in sensors on critical equipment.</p> <p>✓ With systems now in place, the utility intends to move to Reliability Centered Maintenance (RCM).</p>	
14	Performance of the distribution network in terms of system losses	<p>✓ The utility is currently performing well in terms of distribution losses and is able to meet the target of 14 percent set by the regulator.</p> <p>✓ Currently the system losses are around 13 percent and there are plans to reduce them further to 10 percent or less.</p> <p>✓ Lusaka used to be the worst in terms of system losses with about 30 percent losses about 10 to 15 years ago but has since improved following a number of upgrades to the network. [4]</p>	7
15	Efficiency parameters of the distribution network in relation to its capacity (Load Factor)	<p>✓ This is currently not computed but it can be said that the network is almost reaching its capacity as most of the transformers are overloaded.</p>	10
16	Opinion on the critical factors of Operation & Maintenance and how these influence the quality of electricity supply in Lusaka.	<p>✓ <i>Human resource/skills</i> – Manpower with the right skills and the right numbers enhance O&M.</p> <p>✓ <i>Availability of spares/materials</i> – This is important for efficient operations and maintenance.</p> <p>✓ <i>Financial resources</i> – Limited resources affect operations as some materials and equipment cannot be procured.</p> <p>✓ <i>Transport</i> – This is very critical for efficient operations of the utility.</p> <p>✓ <i>Information systems</i> – Modern systems to monitor the network for example, SCADA which enables remote switching.</p> <p>✓ <i>Plans</i> – adequate planning for network reinforcement and upgrading to facilitate expansion and replacement of ageing infrastructure.</p> <p>✓ <i>Modern practices</i> – employing modern business practices such as “live line works” which use insulation equipment to resolve faults without interrupting power supply.</p>	12 8 7 8 5 6 1

i. *Opinions on ZESCOs Operations and Maintenance of the distribution network in general.*

8/15 respondents stated that there were challenges with operations and maintenance as there were bottlenecks in the distribution network resulting in overloaded transformers, system losses and low voltage as the infrastructure was old. The lack of availability of materials also affected operations resulting in delays in attending to faults. On the other hand, 7/15 respondents indicated that the utility was performing well with regards to operations and maintenance owing to a number of on-going upgrading and rehabilitation projects such as the Lusaka Transmission, Distribution and Rehabilitation Program and the Distribution Expansion and Rehabilitation World Bank funded Projects. 2/15 respondents however

noted that in spite of the utility performing fairly well, there were challenges regarding financial resources.

These findings are expected when compared with literature reviewed in chapter 2. As stated by Abu-Elanien and Salama (2009), as a piece of equipment is getting old, the probability and frequency of failure increases thereby requiring more repair time. Maintenance can therefore considerably extend the service life of a piece of equipment, however this becomes costly as the equipment nears its end life. The findings therefore suggest that ZESCOs network has suffered deterioration due to the ageing infrastructure and inadequate maintenance because of insufficient financial resources. Rehabilitation projects currently being undertaken are therefore intended to extend the lifespan of the infrastructure.

ii. Systems, tools and guidelines used to manage the distribution network

13/15 confirmed that ZESCO had a number of systems being used to manage its operations and in maintaining its network. For example, 13 respondents mentioned the Business Integrated System (BIS) which has several tools under it namely; Incidence Management System (IMS); Plant & Equipment Management System (PEMS); Design & Construction Management System; Transport Management System and; Maintenance Management System (MMS). IMS is an operations ICT tool used to manage outages caused by faults on the system while MMS is used in maintenance for planning purposes. For example using MMS, the utility is able to generate what is called the 52 week maintenance plan.

It was noted however from 5/15 respondents that the above systems and tools were only recently introduced and were yet to be fully utilized to optimize operations and maintenance activities. Respondent – R9 for instance indicated that the full benefits were yet to be realized from these systems as currently only about 70 percent of their capabilities were being exploited. In addition, structures to effectively manage the new systems were still being put in place as well as standardization of checklists and maintenance documentation. Another respondent – R13 indicated that the PEMS was another system used to generate weekly schedules and to monitor maintenance activities including generating reports. He however noted that this system was new and was only introduced in the current year.

From the above, the utility seems to have recently introduced these systems and tools meaning that it previously did not have them in place, a situation that could have negatively affected its operations and maintenance activities. Modern Information and Communication Technology (ICT) systems and tools are able to remotely interrogate the network using sensors installed on critical equipment such as transformers and give feedback to a base station. This depends on the type of maintenance strategy being used by the utility. Further, as indicated by respondent – R13 above, these tools such as the MMS are capable of generating maintenance plans and reports. These information systems are an integral part of asset management as can be seen in the relationship between physical assets and other assets in the asset management framework of the Institute of Asset Management's PAS 55-1:2008 (figure 1, chapter 2).

iii. Type of maintenance strategy

10/15 respondents indicated that the main strategy that was being used by the utility was Time Based Maintenance (TBM) which it conducted on an annual basis and in accordance with its 52 week maintenance plan. However, big and critical equipment such as transformers at substations were being maintained using Condition Based Maintenance (CBM). This involved the use of thermal scans to check for “hotspots” and built-in automated sensors which monitored the condition of the equipment before failure occurred. The utility was for example using the Supervisory Control and Data Acquisition (SCADA)

system to remotely manage its critical transformers. Further, the utility was said to be moving towards Reliability Centered Maintenance (RCM) now that systems were in place.

From the previous section (system, tools and guidelines) it can be suggested that the utility's advancements in terms of ICT systems have influenced its maintenance strategy transitioning from Time Based Maintenance to Condition Based Maintenance and moving towards Reliability Centered Maintenance. These findings are consistent with the literature reviewed in chapter 2 where Fernandez and Marquez (2009) argue that a strategy goes beyond just a plan of activities but also reflects a pattern of an organization's goals and policies. It can be seen that the utility's goals are towards Reliability Centered Maintenance which uses a combination of strategies based on how critical a component is to ensure reliability. Further they identify four main types of strategies mostly used by utilities all of which ZESCO is trying to use in one way or another. However as Abu-Elanien and Salama (2009) have stated, TBM requires more manpower, time and money as equipment must be opened up for inspection and maintenance whether or not maintenance is due. This inevitably causes unnecessary outages and is less cost effective thereby affecting the utility's performance.

iv. Performance of the distribution network in terms of system losses

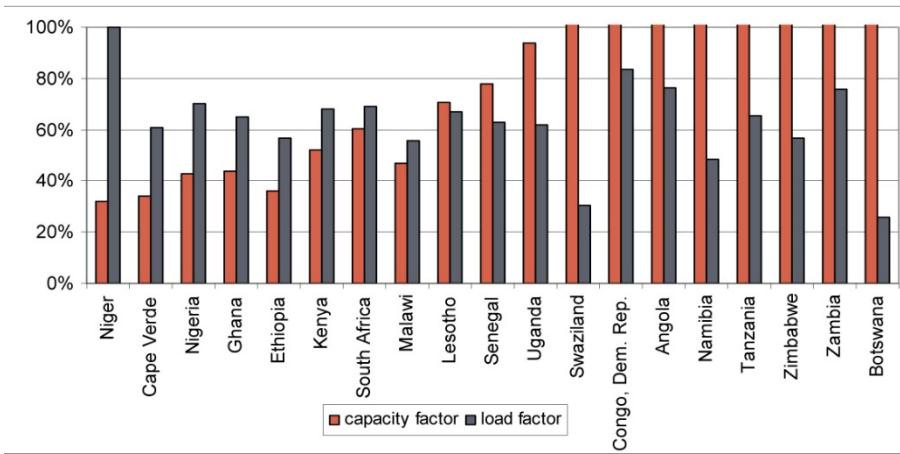
7/15 respondents indicated that the utility was performing quite well in terms of distribution losses and was therefore able to meet the minimum target of 14 percent set by the regulator. The current system losses were said to be around 13 percent and that there were plans to even reduce this further to 10 percent. Lusaka which used to be the worst with as high as 30 percent in terms of system losses 10 to 15 years ago had considerably improved following a number of upgrading projects. According to respondent – R5, the utility now had dedicated teams to control technical losses.

Based on the literature reviewed in chapter 2, 'system losses' is an important indicator used to measure all losses that occur during transmission and distribution in order to determine the system efficiency and overall performance in terms of supplied and billed energy (Tallapragada, Shkaratan, et al., 2009). Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) further states that the optimal range of total system losses is typically between 7 percent and 10 percent in developed countries and below 20 percent in developing countries. This suggests that ZESCO is performing within acceptable standards in terms of this indicator. The findings under this section would therefore be expected based on the fact that ZESCO has to meet the Key Performance Indicator's set by the regulator.

v. Efficiency of the distribution network in relation to its capacity (Load Factor)

10/15 respondents indicated that the Load Factor was currently not being computed. However, 3 respondents stated that the network was almost reaching its capacity as could be seen from frequent faults occurring on the system due to overloaded lines and transformers which point to the network being constrained. Secondary data also suggests that ZESCOs load factor is close to its capacity. Figure 8 shows the load factor compared to capacity factor of selected Sub-Saharan African countries as at 2007.

Figure 8: Load Factor and Capacity Factor - 2007



Source: Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009)

The above metrics show Zambia's load factor in comparison with its capacity factor as at 2007. It can be seen that as at 2007, the load factor was nearing 80 percent which by now should be close to 100 percent due to increased demand. According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), countries that have a high capacity factor coupled with a high load factor are at their physical limit of their capacity. They further state that the load factor helps to determine how close the system is to being overloaded, which means that when the Load Factor is high, the average is only marginally below peak demand and equipment usage efficiency is high. On the other hand it suggests that the system is close to its capacity limit and at a risk of collapse with any potential increases in demand. Therefore as much as respondents indicated that this parameter was not being computed, the “bottlenecks” in the distribution network which were said to be responsible for problems of overloaded transformers mentioned under section (i) (*Opinions on ZESCOs Operations and Maintenance of the distribution network in general*) suggest that the network was almost reaching its capacity. However, the upgrading and rehabilitation projects such as the Distribution Expansion and Rehabilitation Project (DERP) cited in the same section could help in normalizing the utility/s Load Factor.

vi. Opinions on critical factors of Operations and Maintenance and their influence on the quality of electricity supply.

Respondents were asked what they thought were the most important factors of operations and maintenance which influenced the quality of electricity supply in Lusaka. Below are the findings related to this question:

- *Human Resources* – 12/15 respondents stated that the right number of skilled manpower was critical for operations and maintenance.
- *Spares and materials* – 8/15 respondents identified the availability of spares and materials as playing an important role in resolving faults and conducting maintenance.
- *Transport* – 8/18 respondents viewed the lack of transport as a major setback in efficiently conducting operations as availability of transport was key in responding to faults.

- *Financial resources* – 7/15 respondents mentioned the inadequacy in financial resources as having a negative effect on operations and maintenance as without financial resources, materials and equipment could not be purchased.
- *Information systems* – 5/15 respondents cited modern ICT systems such as SCADA which enables remote monitoring and switching as cardinal in developing an efficient operations and maintenance regime.
- *Plans* – 6/15 respondents indicated that adequate planning for network reinforcement and upgrading to facilitate expansion and replacement of ageing infrastructure was critical in ensuring smooth operations and maintenance.
- *Modern practices* – 1/15 respondents cited the adoption of modern business practices such as “live line works” which enables repairs to be conducted without interrupting power supply using insulation equipment as the way forward in operations and maintenance if the utility was to improve performance.

Most of the above findings are expected based on the literature reviewed in chapter 2. *Human resource* and *financial resources* for instance are the main variables being studied in this research whereas *Information systems* although beyond the scope of this study were identified as important non – structural assets using the asset management framework adapted from the Institute of Asset Management’s PAS 55-1:2008 as shown in figure 1 under chapter 2. The establishment and documentation of *Plans* aligned with the utility’s corporate strategy or strategic plan were also discussed under item 2.5.1 in chapter 2 as important to ensure proper maintenance of the asset throughout its life cycle.

Finally, the findings on logistical items such as *vehicles*, *spares* and *materials* though not initially intended to be measured were strongly felt to be critical to the utility’s operations and maintenance activities by the respondents. According to Respondent – R4 inadequate financial resources were significantly impacting on the utility’s ability to purchase operational expenditure items such as spares and materials but also capital expenditure items such as vehicles for operations. Further, as was highlighted in item (ii) under ‘current electricity tariffs’ on *Adequacy*, procurement delays also tend to significantly affect the implementation of operations and maintenance activities.

In summary, the critical factors of operations and maintenance which have had an influence on the quality of electricity supply in Lusaka are outlined below:

- *Systems and tools* – Systems and tools enable the utility to develop maintenance plans and to efficiently manage the network by providing information on critical components for effective decision making. This enhances the utility’s operations and maintenance activities and can thereby improve the quality of electricity supply.
- *Maintenance strategy* – The utility’s efforts to transition from Time based Maintenance (TBM) to Condition Based Maintenance (CBM) directly influences the quality of electricity supply as there is less down-time in terms of outages. This is because TBM requires opening up of equipment regardless of whether maintenance is required or not whereas automation used in CBM reduces the need to open up equipment to conduct maintenance thereby reducing outages. Further, CBM is more cost effective as it reduces the need to travel to monitor equipment and mandatory maintenance as demanded by TBM. This should enable the utility to direct more resources to operations to improve reaction time and thereby improve the quality of electricity supply.
- *Human resource* – The inadequacy in the number of operations and maintenance staff has a direct effect on the quality of electricity supply as currently staff are overwhelmed and unable to respond to faults on time.

- *Financial resources* – Inadequate financial resources due to low tariffs prevents the utility from procuring the necessary tools, equipment, spares and materials to be able to conduct maintenance on all of its assets. This directly affects the quality of electricity supply in terms of frequency of interruptions as equipment becomes unreliable.
- *Spares and materials* – Delays in procuring spares and materials affect the quality of electricity supply in terms of outage durations which tend to increase for as long as materials and spares remain unavailable.
- *Transport* – Inadequate transport causes delays in responding to faults thereby affecting the quality of electricity supply by increasing outage durations.
- *Plans*- Inadequate planning for network reinforcement, rehabilitation and upgrading has had a negative influence on the quality of electricity supply as the network remains constrained and suffers from frequent outages due to overloaded lines and transformers.

4.5 Quality of electricity supply

This section discusses the quality of electricity supply which is influenced by the utility's operation and maintenance activities discussed in the preceding section. According to Holt (2005) the quality of service supplied by a utility is said to be the delivery of services to consumers including activities preceding and following service delivery including network components (hardware and software) through which the service is provided. Further, Holt (2005) states that the quality of service standards can be expressed in terms of performance measures such as the time it takes to restore power following an outage. Table 8 below summarizes the findings on the quality of electricity supply.

Table 8: Quality of electricity supply summary responses frequency table

	Question	Summary of responses	Frequency
17	Opinion on the quality of electricity supply to consumers in terms of unplanned outages.	✓ There are more unplanned outages in the rainy season than in the dry season. This is because of lightening, trees falling on cables and generally roads that are sometimes impassable. As such the utility is not performing well in the rainy season and not meeting the KPI of 7 hours or less wet season outage duration target set by the regulator. Generally performance in the dry season is good. For example on the day of the interview (07/07/15) there were only 15 complaints at Lusaka-Central region whereby in the rainy season you would get as many as 400. [2]	2
		✓ The major challenge is on unplanned outages which are as a result of faults and largely dependent on the reaction time of operations staff. As faults are of a known nature and nothing new, constant monitoring of the network and correct interpretation of information being relayed is crucial in minimizing outage durations.	2
		✓ Currently the performance is not so good due to aged infrastructure. In addition, lack of spares and materials lead to unplanned outages as equipment reliability is compromised. [2]	2
		✓ Unplanned outages are the biggest challenge at the moment other than load – shedding. This is due to	2

		<p>poor maintenance and lack of proper planning for network expansion. As a result the network becomes constrained leading to transformer fuses to blow up. [2]</p> <p>✓ Following investments in network rehabilitation in the past 3 years, improvements are expected in unplanned outages and low voltage problems. For example, the Lusaka Transmission and Distribution Rehabilitation Project has resulted in improvements in the quality of electricity supply. [3]</p>	
18	Performance with regards to key reliability indicators (SAIFI; SAIDI; CAIDI).	<p>✓ These are average indices which even out well. However, indices such as the CAIDI can be quite bad in the wet season. Below was the performance for 2014:</p> <p>✓ For October, November and December 2014, the CAIDI target was 5 hours or less in the dry season and 7 hours or less in the wet season but actual performance was 3.9 for October; 8.01 for November and; 9.38 in December.</p> <p>✓ For SAIFI, the target was 5.5 times or less in the wet season but actual for October was 6.53; 7.68 for November and; 7.36 in December.</p> <p>✓ SAIDI which measures unplanned outages had a target set at 27hours or less in the dry season and 36 hours or less in the wet season. However performance was 18.27 in October; 49.21 in November and; 58.57 in December.</p>	3

i. *Opinion on the quality of electricity supply in terms of unplanned outages.*

2/15 respondents indicated that there were more unplanned outages in the rainy season than in the dry season due to lightening, trees falling on cables and generally difficult working conditions. In addition, roads in some areas become impassable hence prolonging outage durations. As such, the utility was not performing well in the rainy season and not meeting the outage duration target of 7 hours or less set by the regulator. In terms of the dry season, respondents felt that the utility was generally performing well. For example, according to respondent – R13, there were only 15 complaints on the day of the interview (07-07-2015) whereas there would be as many as 400 complaints in the rainy season.

According to 2/15 respondents, the main challenge was on unplanned outages which were said to be as a result of faults and largely depended on the reaction time of operations staff. Respondent – R2, an external respondent, observed that there was nothing new about electrical faults as they were of a known nature and therefore the key was to constantly monitor the network and interpret information being relayed by the system correctly in order to minimize outage durations.

2/15 other respondents attributed the current poor performance to the aged infrastructure and lack of spares and materials which led to unplanned outages.

Another 2/15 respondents blamed unplanned outages on poor maintenance and lack of proper planning to accommodate network expansion leading to the network becoming constrained and resulting in overloaded transformers and frequent fuse blow-ups.

3/15 respondents however noted improvements in terms of unplanned outages following investments in network rehabilitation in the past 3 years, citing the Lusaka Transmission and Distribution Rehabilitation Project which was said to have resulted in improvements in the

quality of supply. According to respondent – R4 improvements started with generation followed by transmission but due to the massive capital investment required, distribution remained constrained whereas generation had improved.

ii. Performance with regards to key reliability indicators.

According to Holt (2005) the quality of service includes technical, commercial and commodity standards. This section looks at technical standards relating to issues of reliability such as the number and duration of service interruptions, whereas commercial standards are considered beyond the scope of this study. These standards are expressed as measures which determine the minimum performance level set by the regulator and expected of the utility.

4/15 respondents indicated that the utility was not performing well on indices such as the Customer Average Interruption Duration Index (CAIDI) which was said to be bad in the wet season, whereas performance in the dry season was good. 3/15 respondents however observed that the performance of the utility with regards to its reliability indicators was improving.

Secondary data was collected from the regulator for the months of October, November and December 2014 and is summarized in table 9.

Table 9: Reliability Indices performance – 2014 Wet season

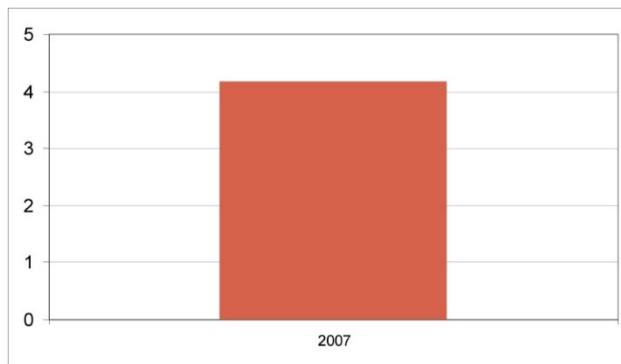
Reliability Index (KPI)	Target (Wet Season)	Month		
		October	November	December
CAIDI	7 hours or less	3.9	8.01	9.38
SAIFI	5.5 times or less	6.53	7.68	7.36
SAIDI	36 hours or less	18.27	49.21	58.57

Source: Unpublished report (ERB, 2015)

As can be seen from table 9 above, the utility's performance in terms of outage durations and interruption frequency has not been good in the wet season and gets worse as the rainy season is reaching its peak. These results are not expected based on improvements in terms of systems; plans; strategies and; upgrading and expansion projects that the utility is said to be implementing. However, these measures are also influenced by the utility's current challenges with its generation capacity which has been outstripped by increasing demand in the last few years resulting in load-shedding.

These findings are consistent when compared with secondary data. According to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009), the main indicator for service quality is the number of outages per year. According to a survey conducted of SSA countries, Zambia's average number of outages in a typical month in 2007 was about 4.2 which translated to 50 outages in a year as shown in figure 9.

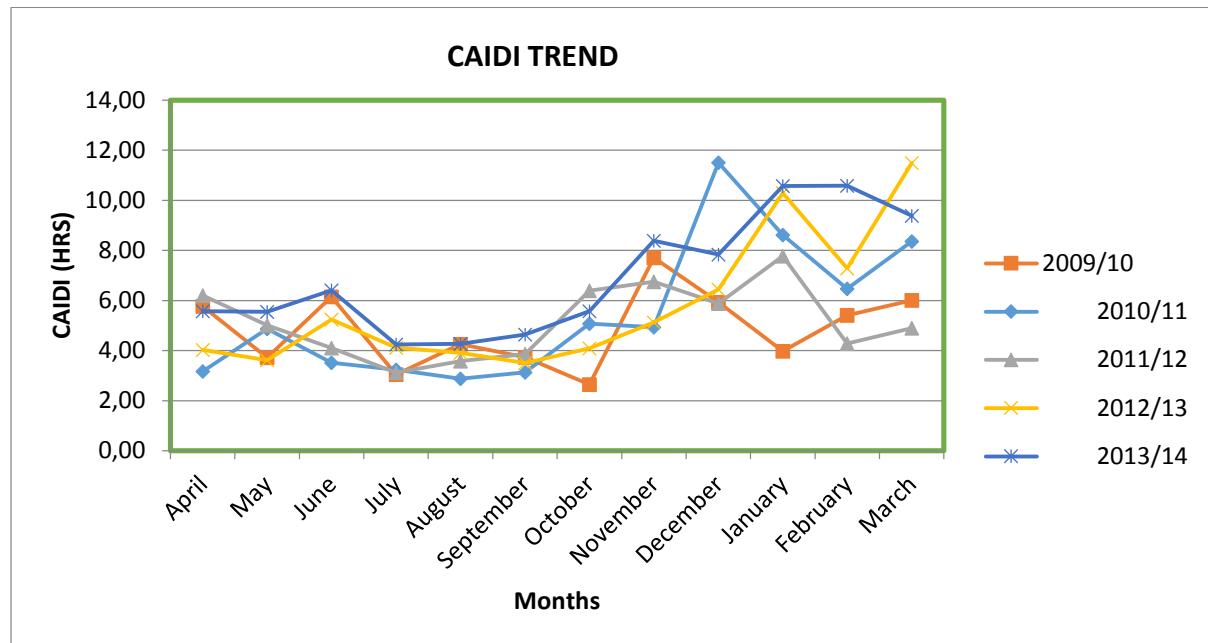
Figure 9: Number of outages in a typical month



Source: Source: Tallapragada, Shkaratan, Izaguirre, Helleranta, Rahman, Bergman (2009)

Primary data on the 3 key reliability indicators was also obtained from the utility for a period of 5 years in order to observe the trend in terms of performance and is shown in figures 10, 11 and 12.

Figure 10: Customer Average interruption Duration Index trend

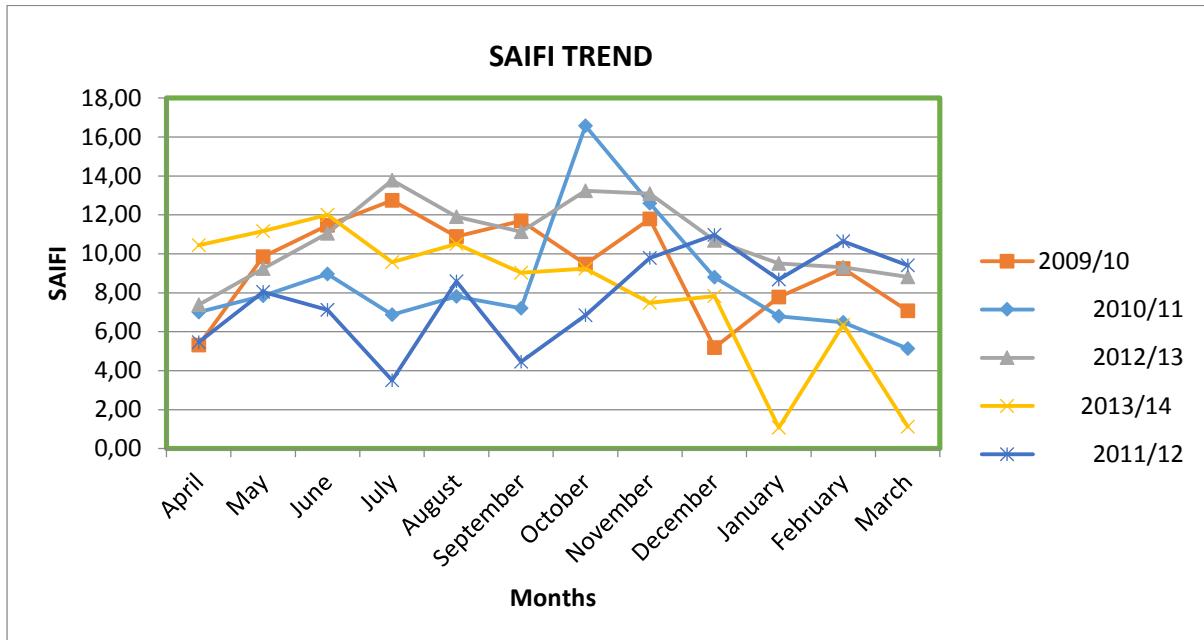


Source: ZESCO, 2015

Figure 10 above shows the Customer Average Interruption Duration Index trend from 2009 to 2014 which shows an upward trend above the set target of 7 hours or less in 2014. This is consistent with the findings from the respondent interviews which indicated that the utility was not performing well in terms of its key performance indicators especially in the wet season. However, according to respondent – R10, there was need to filter the CAIDI index as it comprised both planned and unplanned outages. On the other hand another respondent argued that load-shedding could not be distinguished from an outage caused by a fault from the customer's perspective and so it should also be treated as unplanned. Load-shedding had increased in the last few years due to increased energy demand resulting in an acute energy deficit. This could explain the upward trend in figure 10. Further, as indicated in the other findings, inadequacy in operations and maintenance staff who were said to be serving twice the target customer/employee ratio and unavailability of materials and spares both due to

insufficient resources and delays in procurement could be said to be influencing the performance of the utility in terms of the quality of electricity supply.

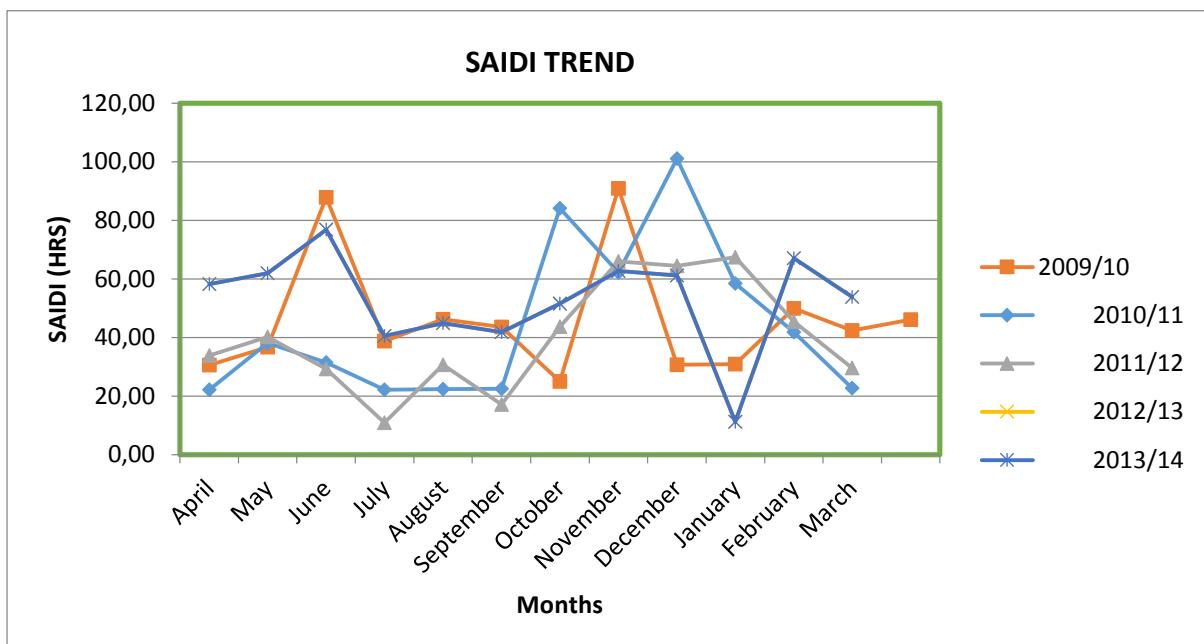
Figure 11: System Average Interruption Frequency Index trend



Source: ZESCO, 2015

In terms of the System Average Interruption Frequency Index, the graph in figure 11 shows a general improvement from 2009 although the 2012/13 performance was extremely poor. However, despite the slight improvement from 2013 to 2014, the utility was still not meeting the upper limit target of 5.5 times or less. However, as has been stated in the previous section, performance in the rainy season is quite bad, which means that the utility could be meeting its target of 5 times or less in the dry season but when averaged, the performance looks generally poor.

Figure 12: System Average Interruption Duration Index trend



Source: ZESCO, 2015

Figure 12 shows ZESCOs performance in terms of the System Average Interruption Duration Index from 2009 to 2014. The target set by the regulator for the SAIDI is 27 hours or less in the dry season and 36 hours or less in the wet season. The graph shows that the performance has been poor with a continued increase in the outage durations. This increase on one hand can be attributed to increased load-shedding and on another hand, the inadequacies in terms of manpower, spares and materials.

In summary, the quality of electricity supply can generally be said to be deteriorating as can be observed from the findings. The main factors influencing the quality of electricity supply as found by this study are; inadequacies in human resource; insufficient financial resources to be able to adequately maintain the network and; operational and maintenance challenges highlighted in section 4.4.3. It can also be seen that the quality is mostly affected be inclement weather in the rainy season. Further, inadequate generation capacity has also heavily impacted the quality of electricity supply as the utility has to load-shed customers at peak-demand.

Chapter 5: Conclusions and recommendations

This chapter draws conclusions from the results obtained during the field visit and presented in the previous chapter. This study began with statement of the problem in which operational and maintenance challenges were identified as negatively influencing the ZESCOs quality of electricity supplied to its consumers. The current challenges were also attributed to ageing transmission and distribution infrastructure which had suffered massive underinvestment over the years. The problem had been further exacerbated by a sharp increase in electricity demand due to increased energy intensive copper mining and a growing population thereby constraining the network even further. Bottlenecks in the distribution network have therefore resulted in overloading of lines and transformers causing frequent power outages. The deterioration in the quality of electricity supply has thus for a long time brought the utility under public scrutiny.

The objective of this research was to explain the extent to which human resource and the current electricity tariffs influence operations and maintenance and how this affects the quality of electricity supply in Lusaka. The previous chapter presented and analysed the qualitative data collected through interviews and supported by secondary data. Based on the findings, it is evident that the utility is facing a number of challenges which are reflecting in the poor quality of electricity being supplied to consumers as can be seen from its reliability indicators which are not meeting the key performance targets set by the regulator. From the evidence gathered during this study, the most notable factors affecting the quality of electricity supply through the utility's operations and maintenance activities were; *inadequate numbers of staff dedicated to operations and maintenance; staff motivation; organizational culture with regards to attitude and; electricity tariffs* which have not been able to adequately cover operational and maintenance costs including investment costs for network rehabilitation and upgrading.

Going by the evidence gathered, the number of operations and maintenance staff was found to be inadequate in relation to the customer/employee ratio set by the regulator. It was found that one operations and maintenance staff was serving close to 200 customers instead of 100 customers as required by the target customer/employee ratio of 100:1. This meant that operations and maintenance staff were overstretched and not enough to adequately undertake operations and maintenance activities. Meanwhile, the overall customer/employee ratio of the whole organization stood at 87:1 suggesting that there were more staff in support functions than there were in operations and maintenance. Historically, ZESCO had been recording increases in its number of employees which according to the 2007 cost of service report were affecting overall productivity and efficiency (IPA Energy Consulting, 2007). It is therefore most likely that more employees were being recruited for support functions at the time. This was common in public utilities in Sub Saharan Africa before structural adjustment reforms which were seen as institutions to help with unemployment (Lesueur and Plane, 1994). An important finding was also that there was a distortion created by the customer/employee ratio which internationally, is designed to measure the number of customers served per employee at a corporate level and not with regards to the actual staff at divisional level who are the customer interface of the organization.

The findings from this study also indicated that the utility did not have an effective performance management system which was affecting employee motivation. Organizations as observed from behavioural theory are made up of individuals whose contribution and performance requires motivation (Greve, H. R. and Argote, L., 2001). The absence of an effective performance management system was therefore affecting productivity of operations and maintenance staff as there was no clear criteria for rewarding deserving employees. Performance based rewards such as promotions, inadequate training opportunities and other incentives such as overtime which had recently been capped at 50 hours per employee in a

month were all cited as having an effect on employee performance. According to Itika (2011), performance based rewards can be in the form of salary increment, renewal of contract, bonus, promotion, training and so on. The lack of such incentives therefore undermines employees' expectations towards their efforts and has an effect on performance as there could be underserving employees getting rewarded in the absence of an objective performance management system.

Employee *attitude* on the other hand which is related to the utility's organizational culture was found to be affecting performance of operations and maintenance staff. This was an unexpected result which was not part of the operationalization of concepts and variables. However according to the principles of modern management, organizations adopt a strategic approach to organizational management which includes setting the organizations mission, values and organizational culture as objectives to promote organizational excellence (Cole and Kelly, 2011). Similarly as was found by one respondent, ZESCO has in its quest to improve employee attitude introduced training on organizational change management. However, as noted with all its training programmes, the lack of adequate financial resources are a deterrent to sponsoring more of such programmes.

In terms of the current electricity tariffs, there was overwhelming evidence both from primary and secondary sources that the current tariffs were below cost and therefore unable to meet operational and capital expenditure. Even though the findings suggested that the budget adequately covered operations and maintenance costs, it was evident that the utility was not budgeting for all items that were due for maintenance due to financial constraints. In addition, the utility's operations and maintenance budget was not being fully utilized due to delays in the procurement process. As such, certain maintenance was not being carried out even when resources were available. ZESCO like all other quasi-government organizations in Zambia follows public procurement guidelines which have many layers of approval and can be a major source of delay. This is because each contract involving public resources expenditure must be signed off by the Attorney General. This significantly affects the utility's efficiency in the purchase of materials and spares considering also that most of these are imported.

The foregoing discussion has so far highlighted the main findings that were identified as affecting the utility's performance in terms of its operations and maintenance activities. Other factors such as; information systems and tools; Plans; spares; materials and; transport were found to be negatively influencing the utility's operations and maintenance activities. In terms of information systems and tools, the utility was found to have a modern BIS system with several tools under it for the management of faults and maintenance. The utility was also using a SCADA system which enabled it to adopt a more efficient and cost effective Condition Based Maintenance strategy. However, the challenge was that the systems and tools were not fully integrated with one another to be able to realize their full potential. Furthermore, there was no long term planning for network expansion and reinforcement which resulted in overloading of lines and transformers as demand was ever increasing. Also paramount to operations and maintenance were spares, materials and transport. Though these were beyond the scope of the measurement, respondents highlighted how their unavailability was influencing operations and maintenance due to insufficient resources. This was compounded by the delays observed in the procurement process. Inadequate transport was also found to be critical especially for operations as this affected response time which was crucial in meeting targets on indices like the CAIDI which measures outage duration.

Consequently, the above mentioned inadequacies in the utility's operations and maintenance activities were affecting its performance in terms of the quality of electricity supplied to consumers as measured by its reliability indicators. Going by the findings, the utility was found

to be performing badly in terms of its reliability indicators especially in the wet season. The CAIDI which is the most important indicator measuring outage duration was found to be within the set target of 5 hours or less in the dry season but was beyond the target of 7 hours or less in the wet season. A 5 year trend analysis of this measure indicated an increase in outage durations which on one hand can be attributed to increased load shedding due to an increasing power deficit but also due to ageing transformers and inadequate maintenance as observed by the findings. Similarly, performance in terms of the SAIDI has deteriorated in the last four years. From the primary data obtained, the SAIDI was particularly bad in the wet season due to heavy rainfall that causes damage to the network but also in the cold season possibly due to high demand for heating requirements. Despite the seasonal extremes the utility was generally performing poorly against its performance targets of 27 hours or less in the dry season and 36 hours or less in the wet season. Finally, the utility has over the last few years recorded an improvement in the performance of the SAIFI even though when averaged, the indicator remains above the target of 5.5 times or less. The improvement can be attributed to upgrading and rehabilitation projects such as the Lusaka Transmission, Distribution and Rehabilitation Program (LTDRP) and the Distribution Expansion and Rehabilitation Project (DERP).

In order to answer the main research question which was to explain “*to what extent human resource and the current electricity tariffs had influenced the service provider’s operations and maintenance activities in improving the quality of electricity supply in Lusaka, Zambia*,” this study posed three sub research questions which are answered based on primary and secondary evidence gathered during this research as follows:

a. What factors of human resource influence operations and maintenance activities?

Based on the findings of this study, important factors of human resource that were influencing operations and maintenance were found to be;

- *Numbers of operations and maintenance staff* – Staff dedicated to operations and maintenance are serving 200 customers per employee. The international benchmark for the customer/employee ratio ranges between 200 and 400 customers per employee in developed countries. However, according to the RERA, SADC utilities customer/employee ratios range from 130 to 180. This is largely influenced by the geographical spread which requires higher personnel overheads. The RERA further cautions that too high a metric may indicate that the utility is not servicing its customers adequately whereas a lower metric suggests inefficiencies. This could be the reason that the ERB has set the indicator at 100:1. The interpretation in this case is that based on the current level of technology ZESCOs operations and maintenance staff may not be able to handle large customer numbers per employee and are therefore understaffed.
- *Staff performance management system* – ZESCO currently has no operational staff performance management system. This means that there are no incentives to reward good performing employees other than across the board bonuses in the form of a thirteenth cheque. This in either case does not motivate employees to strive for excellence as there are no set targets to be achieved. This is supported by the theory of organizational behaviour which recognises that organizations are made up of individuals whose contribution and performance requires motivation (Greve, H. R. and Argote, L., 2001). The view is also held by Liu, Combs, Ketchen and Ireland (2007) who argue that employees must be motivated to make significant contribution beyond their tasks.
- *Organizational culture/attitude* – Although not initially part of the operationalization, the attitude of employees towards work was contributing to the poor performance of operations and maintenance as observed by respondents. In addition, observations

during the process of data collection confirmed that indeed the work culture of some employees left much to be desired. It therefore holds that operations and maintenance staff being the interface of the utility are performing below expectation in terms of their operations and maintenance activities due to a poor organizational culture. This results in unnecessary delays when attending to faults sometimes not due to lack of materials and spares but due to employee mentality.

b. To what extent do the current tariffs meet operations and maintenance costs?

The current electricity tariffs are only marginally sufficient in meeting operations and maintenance costs and fall way short of covering network investment costs required for network rehabilitation and upgrading. Cost recovery which according to Tallapragada, Shkaratan, Izaguirre, Helleranta, et al. (2009) was found to be 38 percent in the case of ZESCO is determined by the cost reflectiveness of electricity tariffs which currently are below cost at \$ 0.06 KWh. To be able to undertake its operations and maintenance activities, the utility uses an activity based budget which is derived from its 52 week maintenance plan. However, due to cost constraints, it can be deduced that the utility uses a selective approach in budgeting for maintenance activities. This means that not all maintenance activities are included in the budget. Using the behavioural theory of organizations to support this argument, decisions in a business are process driven, and focus on price and output (Argote and Greve, 2007). Similarly in this case, the utility's decisions can be said to be based on the cost of operations and maintenance in comparison to the low price of electricity which compels the utility to rationalise its resources by downsizing on certain activities. This results in the utility not being able to maintain the whole portfolio of its assets but instead conducts maintenance based on available resources. Consequently, the lack of maintenance is reflected in the poor reliability of power supply as can be observed from the System Average Interruption Frequency Index which is way above the set target of 5.5times or less indicating that there are frequent faults on the system due to inadequate maintenance.

Based on the foregoing, the current tariffs can be said to be insufficient in covering the current costs of operations and maintenance including capital costs required for network rehabilitation and upgrading. The current network rehabilitation and upgrading projects are being financed through loans from development banks such as the World Bank which ideally should be covered by the tariffs had they been at cost reflective levels. These projects once completed should result in lower operations and maintenance costs, only then can the current tariffs be arguably able to adequately cover operations and maintenance costs. This is because there is a relationship between rehabilitation and costs as found by Schneider, Gaul, Neumann, Hografer, et al. (2006) that utilities need to develop the ability to evaluate the dependencies between maintenance, rehabilitation, costs and the quality of service. However, as demand is constantly growing and the network continuously expanding, it is obvious that meeting operation and maintenance costs will remain a moving target if tariffs remain the same.

c. What are the critical factors of operations and maintenance and how do they influence the quality of electricity supply in Lusaka?

Going by the evidence collected from this study and its interpretation, the factors that are critical to the utility's operations and maintenance which ultimately influence the quality of electricity supply to consumers are as follows;

- *Number of skilled manpower* – As already discussed under sub research question 'a', the number of operations and maintenance staff within the regions is inadequate and therefore overburdened as its customer base continues to grow. This is affecting the quality of maintenance being undertaken on the utility's assets.

- *Financial resources* – Financial resources as discussed in sub research question ‘b’ are inadequate to cover operations and maintenance including upgrading and rehabilitation projects. This means that the utility is not able to maintain all of its assets to the required standard resulting in frequent faults and delays in outage management as reflected in the failure to meet reliability targets.
- *Information systems* – By not fully embracing the use of ICT and automation the utility is not increasing its efficiency in its operations and maintenance activities. Systems and tools such as IMS which is used to manage the incidence of faults and PEMS which is a maintenance management tool should ideally improve the utilities management of its operations and maintenance activities whereas by using SCADA, the utility should have fully migrated to Condition Based Maintenance which is more reliable and cost effective thereby minimizing outages. Currently, the benefit of automation is not being realized as the systems are not integrated despite them being compatible. This is in line with Schneider, Gaul, Neumann, Hografer, et al. (2006) who contend that the challenges currently facing asset managers are not so much the methods of applying asset management but ICT to support asset management decisions. As an example, they cite maintenance related data and reports that are found in databases that are not connected with work management systems which makes it difficult for asset management thereby calling for a need to integrate systems for effective decision making.
- *Maintenance plans* – Until recently, the utility has not had any structured approach to conducting maintenance on its distribution network. However, with the introduction of systems and tools such as MMS and PEMS the utility is able to generate its 52 week maintenance plan to ensure that assets are well maintained. This however, has not led to improved maintenance management due to inadequate financial resources to actualize all the plans which compromises equipment reliability. As such, when a component fails, all three reliability indices are affected in terms of the number of interruptions and the duration of outages measured by the SAIFI, SAIDI and CAIDI. Furthermore, by not planning ahead for network reinforcement and rehabilitation in anticipation for future demand, the utility was always having to deal with a constrained network resulting in frequent failures due to overloaded lines and transformers. This in turn affects the quality of electricity supply in terms of increased outages measured by the SAIFI which in this case had recorded a slight improvement owing to the LTDRP and DERP rehabilitation and upgrading projects.
- *Materials, Spares and Transport* – Materials, spares and transport were indispensable requirements for operations and maintenance which due to inadequate financial resources and delays in the procurement process were negatively affecting the quality of electricity supply. Limited financial resources were preventing the utility from stocking all the materials and spares required for maintenance and fault resolution making it difficult for the utility to resolve faults in good time. Availability of transport on the other hand is essential in ensuring that operations staff attend to faults in good time. The challenges encountered in accessing materials, spares and transport are therefore affecting the performance of operations and maintenance teams in terms of meeting the SAIDI and CAIDI targets which depend on the response time as they measure the duration of outages.

Collectively, the factors identified above are negatively influencing operations and maintenance activities and consequently preventing the utility from meeting its targets on the three key reliability indices which measure the quality of electricity supply. On the operational side, the CAIDI was found to be above the set target of 7 hours or less mainly due to delays in

responding to faults which is directly linked to inadequate numbers of operations and maintenance staff and availability of materials, spares and transport. On the other hand, the SAIFI and SAIDI which measure the frequency and duration of faults on the system are being influenced by the utilities operations and maintenance regime which is largely being affected by insufficient financial resources for the purchase of requisite spares and materials to effectively maintain the network. The performance in terms of meeting the SAIFI is above the set target of 5.5 times of less though has recorded a slight improvement from the previous year whereas the SAIDI was way above the set target of 36 hours or less.

The correlation between operations and maintenance activities and the quality of electricity supply is consistent with the behavioural theory of organizations whose problem solving approach is process-oriented and achieved through physical and cognitive acts within the procedure for the achievement of specific goals (Greve, H. R. and Argote, L., 2001). The process in this case is the operations and maintenance activities of the utility which are influenced by "*physical and cognitive acts*" of the staff involved with operations and maintenance to achieve "*specific goals*" viz a viz the quality of electricity supply measured by the utility's reliability indicators.

To finally answer the main research question which is "**to what extent have human resource and the current electricity tariffs influenced the service provider's operations and maintenance activities in improving the quality of electricity supply in Lusaka, Zambia,**" one must substantiate how one element is more valid or greater than others. It is plausible with the difficulty of determining in quantifiable terms, to what extent human resource and the current tariffs affect operations and maintenance as there are many factors that are involved in the management of physical assets to be able to deliver a service. As can be seen from the asset management framework developed by the Institute of Asset Management's PAS 55-1:2008, the successful management of physical assets depends on other non-structural assets such as human, financial, information, plans, policies and so on. Further, as found by Esmaili (2012), asset management is not only limited to technical activities but also involves business and information management including managing the external environment in which the organization operates. Human resource and electricity tariffs however are inextricable prerequisites in the management of physical assets. Accordingly, the process-oriented view of the behavioural theory of organizations in decision making is held as a fundamental concept in the attainment of the utility's objectives. This is evident from the various units (human resource directorate; finance directorate and; distribution directorate) which were all seen to be working towards supporting the attainment of distribution directorate goals.

As demonstrated by the findings of this study, human resource has been influencing the utility's operations and maintenance activities through; inadequate numbers of staff; lack of motivation and; a poor organizational culture as observed in employees attitude towards work. These factors are compelling enough to deduce that human resource has to a large extent affected the utility's operations and maintenance activities. On the other hand, operations and maintenance activities including human resource itself entirely depend on the availability of financial resources. The current electricity tariffs barely meet operations and maintenance costs and fall far short of covering network investment costs. As observed by Holt (2005), where significant rate adjustments do not occur for a considerable period, a utility may be inclined to enhance its revenue by minimizing operating costs and capital investments thereby compromising service quality. In this regard, it can be deduced that ZESCO is compromising on its operations and maintenance activities due to the low electricity tariffs. Furthermore, delays in the procurement process have exacerbated the situation, making spares and materials unavailable for maintenance works. The current electricity tariffs can therefore conclusively be said to be affecting operations and maintenance activities to a great extent. Consequently, the current

operations and maintenance regime has resulted in no significant improvement in the quality of electricity supplied to consumers in Lusaka which has instead deteriorated under the current circumstances. The conclusion of this research is therefore congruent with Kapika and Eberhard (2013) who contend that although ZESCO had recorded improved financial performance, technical performance had deteriorated. It is indeed true that management according to Cole and Kelly (2011) is simply Planning, Organizing, Motivating and Controlling as all these function can in one way or another be related to the utilities performance in terms of operations and maintenance as demonstrated in this research.

In concluding this research, a reflection on the literature invokes the need to increase the body of knowledge on electricity utilities particularly in developing countries where transmission and distribution are still a natural monopoly. Furthermore, more research is required on the development of acceptable benchmarking standards such as the customer/employee ratio - a common measure of productivity for utilities which was found to create distortions as it is measured at corporate level and does not necessarily reflect the actual numbers of staff that service customers on the ground. This research therefore proposes that the customer/employee ratio should be measured both at corporate level and at operational level.

In similar vein, the reliability indices for developing countries comprise significant interruptions caused by load-shedding which are not necessarily due to faults or maintenance shutdown. This research therefore proposes further inquest on whether indices should be filtered to isolate load-shedding related outages or not. Further research is also proposed on external factors such as the influence of public procurement processes on the performance of commercialized state owned organizations which demand higher levels of authority for public expenditure. This is important as it is a major source of delay in the procurement of goods and services.

Academically, this research demonstrates that behavioural theory of organizations is still evolving since its conception in the later part of the 20th century. In adding to the existing theory it is proposed that the behavioural theory of organizations should embrace more aspects of human behaviour including organizational culture which is influenced by the historical background of an organization as seen in this research. Particularly important here are public organizations which demonstrate a laissez-faire attitude towards work that were found to highly influence the attainment of organizational goals.

In order to ensure validity, this research used an interview manual which was used as the measuring instrument and administered to each respondent while maintaining a log of any modifications. Secondary data was also used to corroborate findings noting variations where encountered. External validity on the other hand was not an objective in this research. The findings are therefore non-transferable to any other organization. However, they could be applicable to other utilities operating under similar conditions as the unit of analysis of this study. In terms of reliability, this research followed a systematic case study protocol according to Thiel (2007) for single holistic case study research. In addition the study maintained a case study log file with is attached as Annex 1.

In closing, it is recommended that in order to improve its performance, ZESCO should focus on improving areas of human resource management identified in this research. Secondly, the utility should address the gaps in its operations and maintenance activities especially the integration of its ICT systems and tools. More importantly, the utility should ensure that it attains cost reflective tariffs by overcoming the tariff barriers identified during the research. In the same vein, the utility should lobby the Energy Regulation Board to sanction automatic adjustments to tariffs based on economic indices such as inflation, exchange rates and so on. Further, the utility should involve the relevant authorities in addressing challenges of

procurement delays as this adversely affects operations and maintenance activities. Lastly, the mines which consume 60 percent of the electricity produced should have their bulk supply agreements reviewed and renegotiated so that they start paying cost reflective tariffs.

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Annex 1: Case study protocol log file

Interviews for this study were conducted between 22nd June 2015 and 14th July 2015 during which a total of 15 respondents were interviewed.

A request to conduct interview based research with the service provider was made prior to the field trip by sending the letter of introduction as provided by the Institute for Housing and Urban Development Studies (IHS) dated April 2015 (see appendix I). Written permission by the service provider was granted on 18th June 2015 as shown in appendix II.

Sampling and respondents

A purposive sample of respondents was developed using a stratified selection according to the layers (top management; senior management and middle management) of the organization and relevant stakeholders as shown in table 1 below.

Annex Table 1: Proposed sample size and distribution of interview respondents

	Position	Department	No.
	ZESCO		
1	Director – Human Resource	Human resource & Admin	1
2	Senior Manager – HR & Training	Human resource & Admin	2
3	Director - Finance	Finance	1
4	Finance Manager	Finance	1
5	Director – Distribution & Supply	Distribution	1
6	Divisional Manager (Lusaka)	Distribution	1
7	Regional Control Centre Manager	Distribution	1
8	Regional Managers (East & Central)	Distribution	2
9	O&M Engineers (East & Central)	Distribution	4
10	O&M Technicians (East & Central)	Distribution	2
	ERB		
11	HER - Electricity	Electricity	2
	MEWD		
12	Planner	Energy Planning Unit	1
	PMRC		
13	Policy Analyst		1
	Total (Sample)		20

Source: Author

However, based on advice from initial respondents within the service provider, it was advised that certain respondents were not appropriate for the research and those that would be beneficial to the research were added to the list. Table 2 below shows the revised list of respondents used in the study.

Annex Table 2: Revised sample list of interview respondents

	Position	Department	No.
	ZESCO		
4	Director - Human Resource	Human resource & Admin	4
1	Senior Manager – HR & Training	Human resource & Admin	1
2	Manager – Human Resource Planning	Human Resource	1
3	Director - Finance	Finance	1
4	Senior Manager – Business Development		1
4	Finance Manager	Finance	4
5	Senior Manager – Budgets & Investments	Finance	1
6	Director – Distribution & Supply	Distribution	1
7	Divisional Manager (Lusaka)	Distribution	1
7	Regional Control Centre Manager	Distribution	4
8	Regional Managers (East & Central)	Distribution	2
9	Principal Engineer (Central)		1
9	O&M Engineers (East & Central)	Distribution	4
10	O&M Technicians (East & Central)	Distribution	2
	ERB		
11	HER – Electricity	Electricity	2
10	Senior Manager - Electricity	Electricity	1
	MEWD		
11	Assistant Director –Power Development	Energy Department	1
	PMRC		
13	Policy Analyst		4
	Kafue Gorge Training Centre		
12	Training Manager		1
	Independent Expert		
13	Former Managing Director (ZESCO)		1
	Total (Sample)		20
	TOTAL		14

Source: Author

The Policy and Monitoring Research Centre also suggested that Kafue Gorge Regional Training Centre (KGRTC) would be more beneficial to the research as they were only concerned with collating information and disseminating to the public. As such KGRTC was included on the list.

Also through previous connections, the author was able to contact a former Managing Director of ZESCO and scheduled an appointment.

Interview Guide (Semi – Structured)

Table 3 shows the semi structured interview guide that was developed for the research.

Annex Table 3: Semi-Structured Interview Guiding Questions

	QUESTIONS	INDICATOR	Means of verification
	Human Resource		
1	What is your opinion on human resources with regards to operation and maintenance in general?		
2	How would you rate the adequacy of Operation & Maintenance staff in relation to customers served in the regions?	<ul style="list-style-type: none"> Customer/employee ratio 	
3	What is your policy on training and continuous and development? If so, how many staff undergo training related to operation and maintenance activities?	<ul style="list-style-type: none"> % staff attending Continuous training & development 	<i>Copy of Training policy</i>
4	Do you have a staff performance management system where rewards are based on the achievement of certain targets and not across the board? Please explain	<ul style="list-style-type: none"> Staff Performance Management System in place 	<i>Copy of Performance appraisal forms/ performance agreement sample</i>
5	ZESCOs staff costs have been said to be high. Could you explain to me what are the factors influencing staff costs and how this affects operating costs?	<ul style="list-style-type: none"> Factors influencing staff costs 	
6	In your opinion, what would you say are the important human resource factors that influence operation and maintenance activities?		
	Electricity Tariffs		

7	What is your opinion on the sufficiency of the current electricity tariffs in meeting operation and maintenance costs?		
8	Are the actual operation and maintenance costs covered by the approved budget?	<ul style="list-style-type: none"> Actual O&M costs vs approved budget 	Approved budget

	QUESTIONS	INDICATOR	Means of verification
9	What is the ratio of the effective tariff against the cost of producing 1 KWh of electricity?	<input checked="" type="checkbox"/> Effective tariff/cost per kWh ratio	
10	ZESCOs tariffs are said to be below cost. What could be the factors preventing ZESCO from attaining cost reflective tariffs?	<input checked="" type="checkbox"/> Cost reflective tariff barriers	
	Operation and Maintenance		
11	What is your opinion on ZESCOs operation and maintenance of the distribution network in general?		
12	Could you tell me about what systems, tools or guidelines that are used to effectively manage the distribution network?	<ul style="list-style-type: none"> Available O&M Plans, work orders, inventories, manuals 	Actual O&M Plans, Sample work orders, inventories, Manuals
13	What sort of strategy does ZESCO employ in maintaining the distribution network?	<input checked="" type="checkbox"/> Type of Maintenance strategy	
14	What is the performance of ZESCOs distribution network in	<input checked="" type="checkbox"/> System Losses	Key Performance Indicators reports

	terms of system losses related to technical challenges?		
15	What are the efficiency parameters of the distribution network in relation to its capacity?	<ul style="list-style-type: none"> • Load Factor 	Key Performance Indicators reports
16	What in your opinion are the most important factors of operation and maintenance and how do they influence the quality of electricity supply in Lusaka?		

	QUESTIONS	INDICATOR	Means of verification
	Quality of Supply		
17	What is your opinion on the quality of electricity supply to consumers in terms of unplanned outages due to technical challenges in the distribution network?		
18	How is ZESCOs performance with regards to its key reliability indicators?	<ul style="list-style-type: none"> • The System Average Interruption Frequency Index (SAIFI) • The System Average Interruption Duration Index (SAIDI) • The Customer Average Interruption Duration Index (CAIDI) 	<i>Key Performance Indicators reports</i>

Conclusion

We have now come to the end of the interview.

Is there anything you would like to add or is there anything you feel I could have left out?

The next step in the research will entail transcribing the interview. As a respondent, you are free to request for the transcript for validation if deemed necessary. Further steps in this research will be to prepare all the data collected for analysis after which a qualitative analysis will be done in order to answer the research question. In conclusion, the findings will be reported and possibly recommendations made. The thesis will be submitted to the school and copy deposited in the Library.

THANK YOU!

Annex 2: Letter of introduction to conduct research



IHS
Making cities work
Erasmus

Institute for Housing and
Urban Development Studies
T +31 (0)10 408 9825
F +31 (0)10 408 9826
E ihs@ihs.nl
www.ihs.nl

TO WHOM IT MAY CONCERN

Rotterdam, April 2015

Dear Madam, Sir,

Herewith we would like to confirm that Mr /Mrs Ernest Zulu from Zambia has been registered as a full-time student in our MSc. Master Course in Urban Management and Development-11 at our Institute, running from 5 October 2014 to 25 September 2015.

The students of this course will need to go on fieldwork to collect data in their home countries from 12th June 2015 and are expected back at the IHS by 19th July 2015 (latest). We support and approve of this fieldwork which is mandatory for all participants in the programme.

We kindly ask you to assist our student in obtaining the necessary information. We would like to stress that the information obtained will only be used for academic purposes and will be treated confidentially.

Your assistance in this respect is highly appreciated.

Best regards,
INSTITUTE FOR HOUSING AND URBAN DEVELOPMENT STUDIES

Dr. A. Ayala Aleman,
Programme Management
Tel.: (31) 10 4089861
a.ayala@ihs.nl

MAILING ADDRESS
P.O. Box 1935
3000 BX Rotterdam
the Netherlands

VISITING ADDRESS
Campus Woudestein
Burg. Oudlaan 50
T-building 14th floor
3062 PA Rotterdam
the Netherlands

B.T.W.
NL 0063.26.766.8.01
K.V.K.
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BANK
42.60.37.944
IBAN
NL54ABNA0426037944
SWIFT
ABNANL2A



Annex 3: Letter of authority to conduct research



Our Ref: A200/HRD/0119/2015

18th June 2015

Mr. Ernest Zulu
C/O National Council for Construction, Central Region
P O Box 39548
LUSAKA

Dear Mr. Zulu,

RE: REQUEST TO CONDUCT RESEARCH

Reference is made to your email dated 16th June 2015, in which you requested ZESCO Management to grant you permission to carry out a research entitled "**To what extent human resources and the current electricity tariffs influence ZESCO's operations and maintenance**".

This serves to inform you that permission has been granted to you on the following terms and conditions:

1. That all information regarding the research should be handled with all the confidentiality it deserves and shall be used for academic purposes only.
2. The final report should be availed to the office of the undersigned before submission to your school for a go ahead in writing.
3. A copy of the final report shall be retained by ZESCO Limited for future reference.

Please fill in the attached form to indicate whether or not you are agreeable to these Terms and Conditions and return a copy to the office of the undersigned.

Yours Sincerely,
ZESCO LIMITED


RHODAH K MWALE (MRS)
SENIOR MANAGER - HUMAN RESOURCE DEVELOPMENT

cc: Director – HR&A
Director – Finance
Director – D&CS
Divisional Manager – Lusaka
RCC Manager
Regional Manager – Lusaka East

All correspondence to be addressed to the Managing Director
ZESCO Limited, Stand No. 6949 Great East Road, P.O. Box 33304, Lusaka - Zambia
Tel: +260-211-361111, Fax: +260-211-222753, E-mail: zesco@zesco.co.zm

/2...

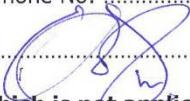
RE: REQUEST TO CONDUCT RESEARCH – MR. ERNEST ZULU

Regional Manager – Lusaka Central
Human Resources Manager - HRD
Principal Human Resources Officer - HRD
Training file

/cm

RE: REQUEST TO CONDUCT RESEARCH (TERMS & CONDITIONS) – MR. ERNEST ZULU

I ERNEST ZULU *agree/do not agree, to the above Terms
and Conditions. Phone No: +260 977 353 440

Signature:  Date: 22/06/2015

***Delete that which is not applicable.**

Witness: CHILESHE MUBANGA Phone No: 0976 205830
Date: 22/06/15

Annex 5: Sample respondent member check confirmation

7/28/2015 (3187 unread) - jez0418 - Yahoo Mail

Home Mail News Sport Finance Style Celebrity Weather Screen Answers Flickr Mobile More

Search Search Mail Search web Home ernest

Compose Back Forward Delete Move Spam More Compose aK

Inbox (3187) Member check/validation (3) People

ernest zulu Today at 1:15 PM

To: anguni@zesco.co.zm

Dear Mr Ng'uni,

Once again, thank you for sparing time for the interview regarding my research conducted on 30 June 2015. As one of the steps to be followed in my research design, I would appreciate if you could validate the attached transcript to ensure I captured the information correctly. Please feel free to add any extra information you may feel could be helpful or indeed to subtract.

I would be grateful if I could get your feedback at your earliest convenience.

Best regards,
Ernest Zulu (Msc. candidate, Erasmus University Rotterdam)

R 01 - ZESCO.docx View Download

Reply, Reply all or Forward | More

Arnold Nguni Today at 3:59 PM

To: ernest zulu

I have read through the responses I had provided and would like to confirm as being captured correctly.

Wish you good luck with your project report.

Regards,
Arnold.

Show original message

***** This email and any files transmitted with it are confidential and intended solely for the use of the entity or individual to whom they are addressed. If you have received this email in error please notify the sender. This message contains confidential information and is intended only for the individual named. If you are not the named addressee you should not disseminate, distribute or copy this e-mail. Please notify the sender immediately by e-mail if you have received this e-mail by mistake and delete this e-mail from your system. If you are not the intended recipient be notified that disclosing, copying, distributing or taking any action in reliance on the contents of this information is strictly prohibited.

Reply, Reply all or Forward | More

ernest zulu Today at 4:01 PM

To: Arnold Nguni

Dear Mr Ng'uni,

Thank you very much for the feedback.

best regards,
Ernest Zulu

Show original message

Reply, Reply all or Forward | More

Click to Reply All

<https://uk-mg42.mail.yahoo.com/neo/launch?.rand=cqho0qtnm6od#7570957435>

1/1



Annex 6: Sample coding list output using Atlas Ti

Code-Filter: All

HU: Interview Coding - 22 July 2015
File: [E:\Atlas Ti Analysis\Interview Coding - 22 July 2015.hpr7]
Edited by: Super
Date/Time: 2015-07-23 14:48:21

CURRENT O&M REGIME opinions on quality
CURRENT TARIFFS activities covered by budget
CURRENT TARIFFS barriers to cost reflectivity
CURRENT TARIFFS opinion on sufficiency
ELECTRICITY cost of production vs tariff
HUMAN RESOURCE Adequacy
HUMAN RESOURCE important factors of HR
HUMAN RESOURCE number of staff attending training
HUMAN RESOURCE Opinion
HUMAN RESOURCE performance management system
HUMAN RESOURCE staff costs
HUMAN RESOURCE training policy
INFLUENCE OF HR & TARIFFS ON O&M
OPERATION & MAINTENANCE general opinions
OPERATION & MAINTENANCE important O&M factors
OPERATION & MAINTENANCE load factor
OPERATION & MAINTENANCE performance - system losses
OPERATION & MAINTENANCE strategy
OPERATION & MAINTENANCE systems and tools used
QUALITY OF SUPPLY opinion on unplanned outages
QUALITY OF SUPPLY performance on reliability indicators

Annex 7: Sample clustering from code output for budget adequacy using Atlas Ti

Report: 12 quotation(s) for 1 code

HU: Interview Coding - 31 July 2015
File: [C:\Users\CB35\Desktop\Thesis 419505\Interview Coding - 31 July 2015.hpr7]
Edited by: Super
Date/Time: 2015-08-01 14:02:43

Mode: quotation list names and references

Quotation-Filter: All

CURRENT TARIFFS Budget Adequacy

P 1: 1:10 [The budget does cover the opex..] (30:30) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]
No memos

The budget does cover the opex activities.

P 3: 3:7 [ZESCO is just managing based o..] (28:28) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]
No memos

ZESCO is just managing based on the low revenue base.

P 5: 5:8 [Operational expenditure is usu..] (27:27) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]
No memos

Operational expenditure is usually covered by the budget but the utility always has to borrow to finance capital projects.

P 6: 6:15 [On paper this should be the ca..] (30:30) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]
No memos

On paper this should be the case. ZESCO comes up with activities of its O&M needs but based on the funding available what is on the ground is different. From inspections that are undertaken, it can be seen that the current funding is insufficient for O&M activities.

P 7: 7:8 [Opex is usually covered by the..] (29:29) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]
No memos

Opex is usually covered by the approved budget. However, procurement delays affect maintenance plans as procurement involves seeking approval from the Attorney General's

office. As a result maintenance items are not procured on time.

P 8: 8:8 [Activities are always covered ..] (27:27) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]

No memos

Activities are always covered by the budget. The utility's budget is subject to the Boards approval on which the respondent sits.

P 9: 9:9 [O&M costs are covered by the b..] (27:27) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]

No memos

O&M costs are covered by the budget even though the implementation of O&M activities does not usually exhaust the allocations in the budget. Only about 60 to 70 percent of the budget is utilized due to delays of seeking authority in the procurement process. However, cost reflective tariffs are still needed in order to sustain the growing customer base.

P10: 10:8 [In most cases O&M costs are no..] (30:30) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]

No memos

In most cases O&M costs are not covered by the budget. Also, the procurement process delays affect O&M activities. In addition to this central stores is not always stocked with spares.

P11: 11:8 [O&M costs are not adequately c..] (28:28) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]

No memos

O&M costs are not adequately covered. Every year there are budget cuts. This is why materials such as meters and cables run out.

P12: 12:8 [In terms of O&M they are more ..] (30:30) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]

No memos

In terms of O&M they are more or less close to budget. This means on the Opex (maintaining plant and equipment etc.) side the utility is managing. This is about 30 percent of the Capex. The utility however faces challenges in the procurement process which takes too much time.

P13: [Currently yes but this was not..] (30:30) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]

No memos

Currently yes but this was not the case two years ago. Anything that is bought must be in the budget. However there is underutilization of the budget. For instance, last year Lusaka Central only utilized 50 percent of the approved budget. This is because plans can be done quite alright but there are procurement challenges.

P14: 14:8 [ZESCO uses an activity based b..] (25:25) (Super)

Codes: [CURRENT TARIFFS Budget Adequacy]

No memos

ZESCO uses an activity based budget. As such, planned activities are always covered by the budget.