UNIVERSITY OF KWAZULU-NATAL

THE OUTSOURCING CHALLENGES AND EFFECTIVENESS OF INSOURCING MAINTENANCE FUNCTION AT ESKOM

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DECLARATION

I, **Bhekani Aaron Ntshangase** declare that

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II. This dissertation has not been submitted for any degree or examination at any other university.

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ABSTRACT

In view of the competition many organizations seek to survive by producing more, with fewer resources, in a shorter period of time (Pintelon and Parodi-Herz, 2008:21). Outsourcing maintenance of production assets over the years has become a popular solution of making the business efficient (Pintelon and Parodi-Herz, 2008:25). Though simple in concept, maintenance outsourcing is difficult in execution, especially in a cost-sensitive environment. There are many cases of failed maintenance outsourcing due to different reasons (Partners in Performance, 2007:1). In such cases, most companies revert to maintenance insourcing to regain control of maintenance activities.

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CHAPTER 1: RESEARCH PROPOSAL

1.1 INTRODUCTION

In an increasingly competitive global marketplace, many companies are looking for some type of advantage over their competition (Favreau, 2007:1). The competitive environment challenges the industries to manage their operations in a cost-efficient and flexible manner. Many companies are critically evaluating their value chains and often decide to reorganize them, and that normally results in focusing on the core business. Consequently outsourcing of some non-core business activities and the creation of new partnerships and alliances are being considered by many organizations (Pintelon and Parodi-Herz, 2008:24). American companies are finding outsourcing to other countries (offshoring) to be a viable option to create cheaper prices (Favreau, 2007:1).

There are reasons why the manager will consider outsourcing a function, but the conventional wisdom regarding the outsourcing decision states that you should outsource your non-core business activities (Dunn, 2007:1). The difficulty with this approach is that it provides no guidance for deciding which activities are non-core. Many companies will be more likely to outsource a function if there are multiple reasons for doing so (e.g. acquisition of new skills, acquisition of better management, focusing on core functions and improving flexibility). While there are many good reasons to outsource a function there are also a number of risks associated with it, e.g. non-performance by the supplier (Dunn, 2007:1).

As organisations today strive to achieve minimum operating costs and lean operations in terms of manpower, the maintenance activity has become a target for outsourcing. With a growing shortage of skilled and experienced maintenance engineers, facility management companies provide an attractive alternative to the traditional approach to maintaining assets. However, for many organisations, maintenance is close to the core of their operations and the decision to outsource is a difficult one (Levery, 1998:1). Eyes on China (2008:1) highlights that globalization and technology advances have

challenge the principle of focusing on core business. It further advances that core business processes are no longer seen as proprietary information. Therefore large and small companies are seeing both core and non-core business functions as dispensable components they can retain internally or offload to external strategic partnerships (Eyes on China, 2008:1).

Outsourcing maintenance of production assets over the years has become a popular solution of making the business efficient. Besides the traditional outsourcing of maintenance activities to equipment suppliers or the use of some small local firms, there is nowadays a growing market of medium sized and large outsourcing firms. These firms offer a range of consulting support, specialized services and even full service to allow strategic outsourcing to work (Pintelon and Parodi-Herz, 2008:25).

The governments around the world have move away from the traditional way of performing services like road maintenance and street light maintenance. In South Africa the majority of the municipalities have stimulated the Black Economic Empowerment (BEE) through outsourcing some of the services that was previously performed in house. The government - public participation in delivering critical service has became the norm, especially in trying to eradicate poverty and distribute the economy. In critiques of public sector as a sole service provider the Durban Metropolitan Unicity (2000:27) notes that the local governments in developing countries including South Africa have a desperate need to mobilise finance and managerial capacity capable of taking on projects to deliver services to millions of people. The scale of the projects is often too large and impractical for local government to go it alone.

There is a vast amount of literature about outsourcing as a management tool, but very little information about the detailed successes of outsourcing. Mather (2003:2) argues that even though outsourcing is generally one of the solutions to reduce operations costs, but there is no quantifiable proof of this statement. He further qualifies that where there are cost benefits they need to be measured alongside the trade-offs that will have been made to achieve such savings. Trade-offs such as the economic focus of the contractor being

different to that of the asset owner, trade-offs in terms of differing work cultures when there has been an integrated approach and also trade-offs in terms of who owns the asset knowledge base. No amount of contractual maneuvering, nor processes can change the fact that when contractors do work, they learn about the assets (Mathier, 2003:2).

According to Partners in Performance (2007:1) the numbers of reported cases of failed maintenance outsourcing are due to misjudged decision on whether to outsource or not, customer does not understand maintenance or how to manage it, the contract incentives are not aligned to maximizing customer profit and failure to deliver. The maintenance outsourcing as a strategic tool to drive efficiency must realize all the predetermined results. Where outsourcing failures has occurred, most companies will normally revert to in-house maintenance (insourcing).

The effectiveness of the maintenance service whether insourced or outsourced cannot be measured with the cost benefits alone. The equipment that is properly maintained will run for a long time without failure, hence improve the reliability and availability of the plant. Therefore it becomes very important to pass on the equipment performance to the contractor by including the performance target in the outsourcing contract (Levery, 1998:4).

1.2 BACKGROUND

Eskom was established in 1923 as an Electricity Supply Commission that was responsible for establishing and maintaining electricity supply. Eskom was established to unify the electricity body that will managed large decentralized power stations, which in turn would offer more reliable and cheaper electrical power than small dedicated power stations (Conradie & Messerschmidt, 2000:75). In 2008 Eskom was among the top nine electricity utilities in the world in term of sales. It was one of the top 13 utilities in the world by generation capacity. It generates, transmits and distributes electricity to millions of customers within and outside the South African border. Eskom generates approximately 95% of electricity used in South Africa and 45% of

electricity used in Africa. Electricity is generated closer to the coal reserves and transmitted over a long distances transmission lines to the customer load centers (Eskom, 2008: i).

Eskom operations are run by three core divisions namely: Generation, Transmission and Distribution (Eskom, 2008: ii). Generation Division activities include expansion, operations and maintenance of the power stations to satisfy the countries electricity requirement. Transmission division activities include expansion, operations and maintenance of the high voltage network between the power station and low voltage distribution network. Distribution division includes expansion, operations and maintenance of low voltage network that directly supply the customers. The Eskom operations comprise of a number of interconnected power systems that is linked up to deliver electricity across their Southern Africa (Eskom, 2008: iii).

In 1913 the Central Maintenance Services was formed by power producers to maintain equipment for the power stations. It continued to exist after the establishment of Electricity Supply Commission servicing all the power stations. In 1989 a new company called Rotek Group was established and all the assets and operations of Eskom's Central Maintenance Services were transferred into an independent holding company, namely Rotek Industries (Proprietary) Limited, of which Rotek Engineering is a division. Rotek was incorporated into Eskom Enterprises (an unregulated Eskom Division) during 1999 but still operating as an independent entity with its processes and procedures. With over 90 year's experience, Rotek Engineering remains the market leader in Africa in the maintenance, repair and refurbishment of power generation and transmission equipment (Rotek Engineering, 2008:1). All the maintenance activities previously done by Central Maintenance Services were outsourced to Rotek Engineering.

Transmission East Grid is a business unit of Eskom Transmission Division which is responsible for all the Transmission operations in KwaZulu Natal. The bulk electricity generators are located in Mpumalanga province and they supply all the electricity requirements in South Africa (Mtolo, 2009:47). The

interconnected Transmission networks transport electricity from generators to the different load centres. The KwaZulu Natal transmission network comprises of 24 substations interconnected by 4 756 kilometers of high voltage transmission lines, as shown in Figure 1.1. This network supplies electricity to the biggest users of electricity in Durban and Richards Bay areas (Mtolo, 2009:49).

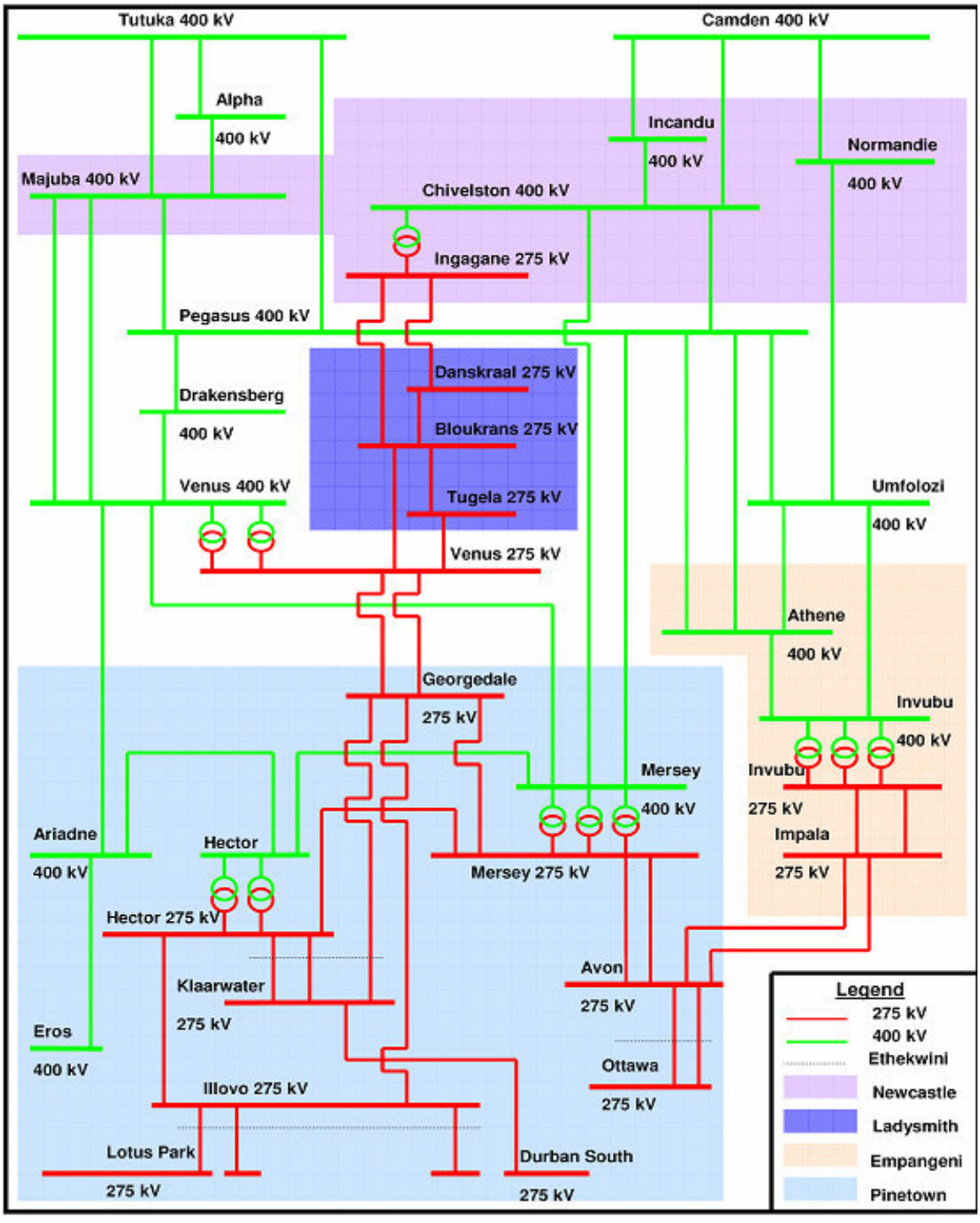

Figure 1.1 Transmission East Grid high voltage network (Mtolo, 2009:49)

The transmission lines run through different terrain from the power stations to the customers, and that can pose different risk to the line performance. The common threat to the transmission lines is vegetation growing under the line. The tree growing under the line can bridge the electrical gap between the line and ground, and cause a fault (Phillips, 2006:9-6). The fault in the interconnected electrical network will normally cause voltage depression that can disturb the production of the end users. Therefore line fault is an undesired condition which must be avoided through design and maintenance, and its impact must be minimized as much as possible. Figure 1.2 shows the risk of tree under the high voltage lines.

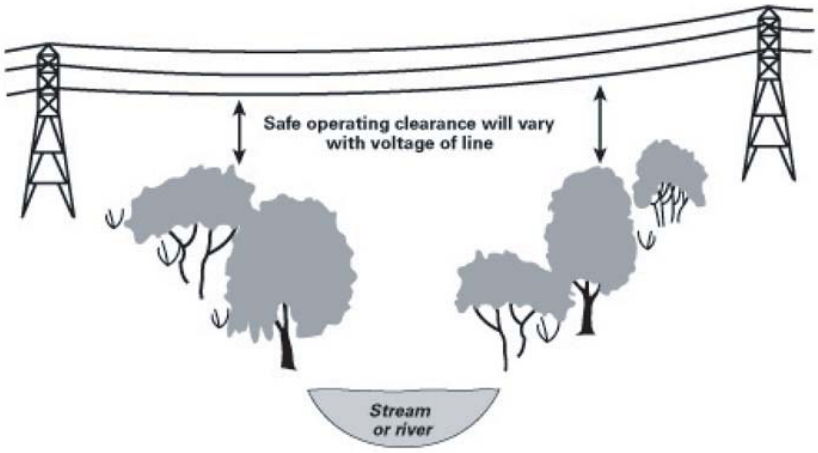

Figure 1.2. Tree growing under high voltage line (Phillips, 2006:9-6)

In between the power stations and the customers there are number of facilities built to enhance reliability of the network. A substation is a high-voltage electrical facility located between the generation and transmission systems, or between transmission systems, or between transmission and distribution systems. The substation is equiped with a number of equipment to enhance the reliabilty of the electrical network (ABB, 2006b:5). The circuit breakers and power transformers are the most important part of the substation, they both have major contribution to the availabilty of electricity supply than any other equipment in the substation.

The transmission lines are terminated at the substation with switching equipment called circuit breakers. A circuit breaker is an apparatus in electrical systems that has the capability to, in the shortest possible time, switch from being an ideal conductor to an ideal insulator and vice versa.The circuit breakers have got two functions: firstly to switch the line out of service during maintenance and switch back to service, and secondly to automatically isolate the faulted line without affecting the rest of the network. Therefore the circuit breaker improves the electrical system reliability by minimizing isolating of plant under fault condition (Roininen *et al*., 2009:8). Figure 1.3 shows the pictures of high voltage circuit breakers.

Figure 1.3. High Voltage Circuit Breaker (Roininen *et al*., 2009:8)

A power transformer is an electrical apparatus that enable the connection of electric circuit at different voltage. The high voltage transmission line are used for transmission of electricity over a long distance, and then the transformer at the substation is used to reduce voltage to one required by household and industrial equipment. Therefore the function of the transformer is to regulate the electricity voltage to the useable level as required by the customers (Lee, 2002:2-95). Figure 1.4.shows the power transformer.

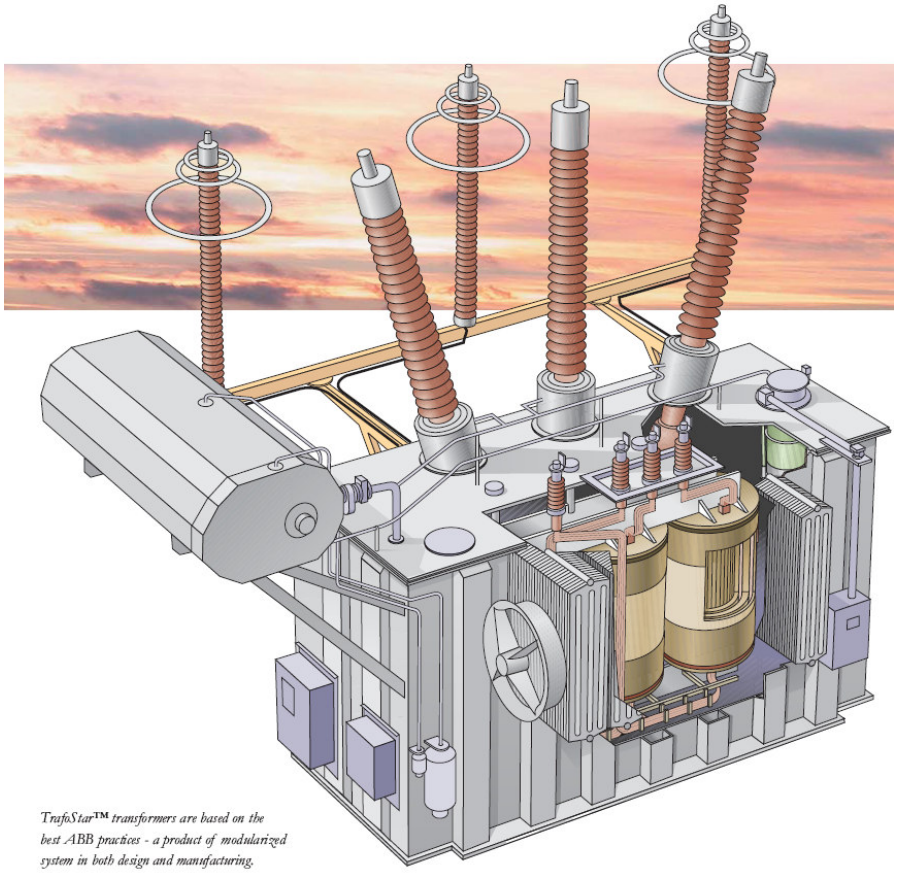

Figure 1.4 Power Transformer (ABB, 2006:7)

Both transformer and circuit breakers are robust with moving parts that operates to interrupt current under normal and abnormal conditions. Therefore they both require some maintenance intervention to operate effectively.

1.3 PROBLEM STATEMENT

The Eskom document Western Cape electricity supply (2006:2) reviewed the power failures and loadshedding incidents in the Western Cape due to multi-technical failures. On 11 November 2005 a number of major events relating to the electricity supply started in the Western Cape network. The first incident was due to transmission lines and generator failures at Koeberg power station which was caused by a mechanical failure on the 400kV switchgear. This was followed by 400kV transmission lines failures due to fire burning under the lines on 16 November 2005, and the generator failure at Koeberg which was caused by a foreign object which damaged the generator stator and the

rotor on 25 December 2005. On 28 February 2006 the insulator pollution flashover on Western Cape major line caused a blackout in Cape Town.

There was a general public concern about the quality of maintenance in the Eskom network after these incidents. In 2007 National Energy Regulator of South Africa (NERSA) instituted an audit to fulfill its mandate to ensure that Eskom Holdings complies with the National Transmission license and Grid Code, amongst other regulations prescribed by the regulatory authority. The objective of the audit was to determine the status and effectiveness of the ESKOM Transmission maintenance strategy, expansion plans and philosophies, and to determine the execution and success of the ESKOM Transmission maintenance plan (NERSA, 2007:3). Although the auditors found the transmission grid to be in a good condition and well maintained, a number of risk areas were identified, which if not attended to in time, could increase and eventually result in non-compliances and associated network failures (NERSA, 2007:12).

The Western Cape incidents and the NERSA audit highlighted the need for continuous assessment of maintenance effectiveness in the East Grid network. In September 2003 the Transmission East Grid took over the maintenance of circuit breakers and isolators that was previously outsourced to Rotek. The driver to the change the sourcing decision was the contractor's (Rotek) poor workmanship and high maintenance costs. There was no study done after the maintenance insourcing decision to determine the effectiveness of the new maintenance strategy. In 2008 East Grid had five years of experience in maintenance insourcing of circuit breakers and isolators. Therefore it was essential for the East Grid conduct its own study to determine the maintenance performance successes and challenges. The study was to enable the Grid to understand effect of maintenance outsourcing and insourcing on plant performance in Transmission East Grid.

Transmission East Grid runs a large number of assets that are distributed through the KwaZulu Natal province country, and those assets needs frequent maintenance to continue operate at acceptable level of performance. Because

of the size of the equipments and specialized nature of maintenance, all the maintenance activities were done by Central Maintenance Services which later became an independent company called Rotek Engineering. Rotek Engineering was equipped with state of art equipment and tools to execute all the high voltage equipment maintenance. A lot of resources were put in to ensure that Rotek had highest trained and qualified personnel to deliver the required services.

The maintenance policy of Transmission since its formation in 1992 was more preventative, with small pockets of condition base maintenance (Dixon, 2008:2-13 & Nkosi, 2009:3-16). The maintenance management system was designed such that the first line maintenance, work identification, planning, scheduling and history recording was done in-house, and only maintenance execution was outsourced to Rotek. The yearly maintenance schedule was put together by the Grid and communicated with Rotek for resource planning. The Grid will further arrange the outage, and on the day of the outage Eskom staff will isolate the plant and make it safe for maintenance, and Rotek will execute the required maintenance.

The maintenance contract run for 3 years, and it covered all planned, unplanned and breakdown maintenance. Rotek also provided the technical investigation to the plant failures and conduct major repairs on critical plant like transformers and generators on site and at the workshop. One of the shortcomings of Rotek maintenance outsourcing contract was that the contract incentives were not aligned to the maintenance performance. The maintenance contract was not linked to any performance related improvements.

Partners in Performance (2007:1) noted that where the contract incentives are misaligned, the customer typically feels a lot more pain from poor maintenance than the supplier does. In 2001 the equipment performance was discussed at different national forums, and the feeling from the majority of Transmission Grids was that Rotek service has deteriorated and maintenance costs were too high. This perception drove some Transmission Grids to take

over the previously outsourced maintenance service. The Transmission Grids was also taking an advantage of the equipment suppliers who were willing to train the Grid staff in maintenance. There was no strategic decision made by senior leadership with respect to maintenance outsourcing, however all the Grids could decide on sourcing options based on available resources.

Transmission East Grid had number of challenges that also drove them to tactically reduce outsourced maintenance to Rotek Engineering in 2003.

- There were a significant number of equipment failures after maintenance.
- There was an increasing number of return jobs due to poor workmanship.
- There were catastrophic failures that were not only affecting adjacent equipments but also causing severe voltage depression in the network.
- The breakdown costs were escalating, and thus pushing up the insurance subscription.

1.4 RESEARCH OBJECTIVES

The improvement on maintenance management can involves the efforts of both internal staff and external service providers. However an understanding of the maintenance key performance indicators is essential in tracking future trends and determining improvements or best practices in the management process.

The objective of the study was to identify the maintenance key performance indicators (KPI's) and use these KPI's to evaluate the challenges and success of maintenance outsourcing and insourcing in Transmission East Grid between 1998 and 2008. The aim of the research was first, to gain an understanding of maintenance outsourcing and insourcing, including the identification of the drivers, the critical success factors and the benefits. This information was used to identify the critical performance measures that could be used to analyze the effectiveness of maintenance activities in Eskom Transmission. The following performance measures were identified to

evaluate and compare the effectiveness of maintenance outsourcing and insourcing.

- Equipment performance.
- Equipment Reliability (Mean Time Before Failures) and Availability.
- Recovery Time (Mean Time To Repair).
- Maintenance budget.
- Sustainability of maintenance insourcing.

1.5 RESEARCH QUESTIONS

The research was attempting to answer the following questions:

- How was the performance of circuit breakers and transformers in East Grid?
- How was the maintenance performance prior to maintenance insourcing?
- What improvements were brought by maintenance insourcing in 2004?
- How sustainable is maintenance insourcing in the East Grid?
- How sustainable is maintenance outsourcing in the East Grid?

1.6 IMPORTANCE/SIGNIFICANCE OF THE STUDY

This research will assist Eskom or any other organization who are looking at improving efficiencies through outsourcing. Where outsourcing has given unexpectecd results, this research will assist with possible options to improve the situation.

1.7 RESEARCH DESIGN AND METHODOLOGY

The research approach followed a quantitative approach. In quantitative research, the internal secondary data from Eskom maintenance databases was gathered used to analyzed the equipment performance during outsourcing and insourcing period. In addition to equipment performance analysis, the survey research was conducted through the use of questionnaire on maintenance staff to evaluate the sustainability of maintenance insourcing.

1.8 ETHICAL REQUIREMENTS

Because the information in this research might be very sensitive, the permission has been granted by the senior management to use the information.

1.9 REPRESENTATIVE SAMPLING

To maintain a good representative sampling the survey covered the whole population of employees who are involved in maintenance. The standard questionnaire was used for all the participants.

1.10 DATA ANALYSIS

The data was analyzed using statistical methods, spreadsheets and the result were presented using graphs.

1.11 LIMITATIONS OF THE STUDY

The findings of this research will be more appropriate to the electricity industry, where the equipments to be maintained are decentralized. Therefore it is not easy to keep the service provider in your premises like other industries. Other utilities like water suppliers, telecommunications can also benefit from this study.

1.12 STRUCTURE OF THE THESIS

In the earlier section the introduction to the background and motivation is given. The increasing acceptance of maintenance outsourcing as the cost cutting measure, and the challenges leading to reversed outsourcing has motivated this study. The traditional outsourcing decision was based outsourcing the non-core activities, but even maintenance activities that were considered to be core has become a candidate for outsourcing. However the success of outsourcing cannot be guaranteed all the time, the loss of skills affect all industries. In the following chapters more discussions regarding outsourcing, insourcing and maintenance are presented.

Chapter 2 covers the background work which includes the literature review for this study. The literature review gives the in depth study in outsourcing and insourcing, and its relevant in maintenance management.

Chapter 3 introduces the methodology used to conduct this research, this chapter covered the research design used to answer the research questions, explains the research instruments, and the data analysis used.

Chapter 4 and 5 present the main results and discussion on the findings.
Finally, Chapter 6 provides general conclusions and recommendations

1.13 CONCLUSION

As organisations today strive to achieve minimum operating costs and lean operations in terms of manpower, the maintenance activity has become a target for outsourcing. Outsourcing maintenance of production assets over the years has become a popular solution of making the business efficient. However, for many organisations, maintenance is close to the core of their operations and the decision to outsource is a difficult one. Outsourcing can also bring unexpeced results which might be difficult to reverse. The purpose of the study was to evaluate the challenges and success of maintenance outsourcing and insourcing in Transmission East Grid between 1998 and 2008. This chapter provided an overview of the background and motivation of this research, and outlined the research goals and questions that this study seek to achieve. The research methodology deployed for this study as well as a short presentation of chapters in this report are also provided. The limitations of this study is also given.

The literature review on this reaserch is presented in the next chapter (chapter 2).

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Traditionally, maintenance has been a core in-house activity. However, it is now being viewed by many organizations as a non-core business function, and outsourcing of the maintenance function has become an increasingly widespread practice. The concept is that the manufacturer may then fully focus attention and resources on its core business processes, while receiving a high-quality service at a lower cost from external contractors. Outsourcing maintenance activities is especially common in the servicing of office equipment, airplane engines and brakes, hospital equipment, information technology, and production machines in manufacturing plants (Taracki *et al*., 2006:81).

Utilizing external talent and expertise to carry out certain operations is a widely adopted practice these days across many industries, helping to reduce costs, improve productivity and save time (Brock, 2004:1). A big part of the outsourcing equation, particularly for managers facing hiring freezes, cuts in training budgets, ageing maintenance workforces, and hard-to-find skilled labor pools, is maintenance outsourcing (Olive, 2004:1). Today, maintenance outsourcing provided by outside vendors is covering more and more maintenance tasks once handled by in-house staff. Outsourcing enables budget flexibility by enabling the organizations to pay for only the services they need and when they need them. It also reduces the need to hire and train specialized staff, brings in engineering expertise from the outside, and reduces capital expense, yielding better control of operating costs. The outsourcing arrangement can change as your maintenance needs change (Olive, 2004:1).

Energy companies are also facing a challenging environment that requires them to manage their operations in the most cost-efficient and flexible manner (Dalal, 2005:1). The Competition Commission Research Report (2007:1) highlights that there is a long and the complicated history in the development of the electricity supply industry (ESI), and its relationship to the political

process. The traditional utility is expected to extend service to meet the needs of a growing population and the growing energy appetite in its franchised service area (Trendaway, 2002:2). However in the developing countries like South Africa where the majority of population prior to 1994 did not have electricity, there is a big pressure from government to expand the electrification programme. Eskom Distribution is still involved in a massive electrification programme, which aims at having all homes in the country electrified by 2012 (Competition Commission Research Report, 2007:15). These network expansions and demand for quality and low cost services should go hand in hand with good maintenance strategies. These expansions also spread the equipment base to the remote areas, and that require better maintenance management of an ever-growing set of widely dispersed assets.

The form of regulation in the electricity industries is changing. Today, investor owned utilities are subjected to intense regulatory pressures as regulators move away from the concept of cost-based return to performance-based return. Utilities are increasingly realizing that their ability to generate returns for shareholders is constrained. According to Curt Volkmann, associate partner with Andersen Consulting's Utilities Practice, there are really only four ways to increase returns to shareholders: reduce costs, increase revenues from existing assets, generate the same revenues from fewer assets and invest in new assets that generate returns commensurate with business risk (Bush, 1999:1).

In addition to the expanding networks, there is an increasing environmental awareness towards reducing emission and driving for green power. This put pressure for improved operational excellence like reducing the use of fuel like coal and nuclear. This should be achieved without compromising the reliable services of electricity supply at affordable rates. In meeting these increasing challenges electricity providers are required to strike the balance between reducing costs and managing risk (safety or environment).

In order to meet these challenges some utilities have turned to outsourcing the maintenance of infrastructure assets. This growing practice allows utilities to quickly scale resources while simultaneously reducing overheads, without disrupting or degrading key services to the customers. Outsourcing is one of the management strategies that can help, but only if it is designed, implemented and managed effectively (Dalal, 2005:1)

However, outsourcing brings its own sets of challenges, the worst being the poor performance of the outsourcing company. A survey conducted by the National Energy Regulator in 2003 found that 49% of municipalities had no maintenance strategies for their electricity distribution networks and lacked understanding of power quality and performance issues. This means that almost half of the country's municipalities do not carry out routine maintenance checks and do not have contingency measures to deal with power cuts. The survey also found that about 45% of electricity distributors are failing to identify areas requiring corrective action (EDI). Most of these municipalities rely on outsourcing services to lead their expansion and repair breakdowns (Competition Commission Research Report, 2007:16).

2.2 MAINTENANCE

To discuss the context in which maintenance outsourcing is embedded, one may raise the question what is maintenance as such? Most authors like Moubray (2001:7) and Singh and Pycraft (1997:711) in maintenance management literature agree on defining maintenance as the "set of activities required to keep physical assets in the desired operating condition or to restore them to this condition". This imply that maintenance is all the actions taken to prevent a device or component from failing or to repair an equipment that was degraded by an operation and keep it in proper working order (Sullivan *et al.*, 2004:5.1).

While the above maintenance definition may suggest that maintenance is simple, but in reality maintenance management involve a complex and dynamic process required to implement maintenance practice that improve the operations performance. The key objective of maintenance management

is to maximize the availability and reliability of the assets and equipment to produce the desired quantity of products, within the required quality specifications, in a timely manner. Obviously, this objective must be attained in a cost-effective way and in accordance with environmental and safety regulations (Pintelon and Parodi-Herz, 2008:22).

Good health of any company depends on operations equipments that are kept in proper working order (Campbell, 1995:1). Nothing lasts forever and all equipments are associated with some predefined life expectancy or operational life. The design life of most equipment requires periodic maintenance, belts need adjustment, alignment needs to be maintained, and proper lubrication on rotating equipment is required. In some cases, certain components need replacement, e.g., a wheel bearing on a motor vehicle, to ensure the main piece of equipment last for its design life. Anytime we fail to perform maintenance activities intended by the equipment's designer, we shorten the operating life of the equipment (Sullivan *et al*., 2004:5.3).

In any operations failures can have undesired consequences, it may affect operations, production quality, safety or environment. But the right maintenance intervention will bring the following benefits, namely:

- **Increased reliability**: This leads to less disruption to normal activities of the operation (Singh and Pycraft, 1997:711).
- **Lower operating costs**: Most equipment run more efficiently when regularly serviced (Singh and Pycraft, 1997:711).
- **Enhanced safety:** Well maintained machine are less likely to behave unpredictable or fail outright or caused something that can pose hazard to staff (Singh and Pycraft, 1997:711).
- **Longer life span**: Regular care, cleaning or lubrication can prolong the effective life of machinery by reducing the small problems in operation whose cumulative effect causes wear or deterioration (Singh and Pycraft, 1997:711).
- **Higher quality**: Badly maintained equipment is more likely to perform below standard and cause quality errors (Singh and Pycraft, 1997:711).

- **Higher end value**: Well maintained machined can be easily disposed of into the second hand market (Singh and Pycraft, 1997:711).

2.2.1 Types of maintenance

Over the last 30 years, different approaches to how maintenance can be performed to ensure equipment reaches or exceeds its design life have been developed. In addition to waiting for a piece of equipment to fail (reactive maintenance), preventative maintenance, predictive maintenance, or reliability centered maintenance can be used as one of maintenance philosophies (Sullivan *et al.*, 2004:5.1). In practice the maintenance activities will consist of some combination of the following approaches:

2.2.1.1 Reactive maintenance or Run to breakdown

This approach allows the machinery to run to failure without any intervention. Maintenance work is performed after failure has taken place. The advantages to reactive maintenance can be viewed as a double-edged sword. When dealing with new equipment, one can expect minimal incidents of failure. If the maintenance program is purely reactive, there will be no money spent on labour and maintenance costs until something breaks. This approach can be viewed as saving money especially during the quiet period. However the reality is that you are really spending more money than you would have under a different maintenance approach. The reason is that breakdowns happened when unexpected, therefore it requires more manpower, more materials and more time. It is estimated that the cost of a breakdown is normally three to four time the planned maintenance costs. Reactive maintenance is associated with large material inventory of repair parts. This is a cost that can be minimized under a different maintenance strategy (Sullivan *et al.*, 2004:5.1-2).

2.2.1.2 Preventative maintenance

Preventative maintenance approach attempts to eliminate or reduce the chances of failure by services the machinery at pre-planned intervals. This type of maintenance is practiced where consequences of failure while in service can have serious consequences (Singh and Pycraft 1997:711). By

simply spending the necessary resources to conduct maintenance activities, equipment life is extended and its reliability is increased.

In addition to an increase in reliability, preventative maintenance will save more money than using reactive maintenance. Studies indicate that this savings can amount to as much as 12% to 18% on the average. This approach will not prevent equipment catastrophic failures, but it will decrease the number of failures. Minimizing failures translate into maintenance and capital cost savings (Sullivan *et al*., 2004:5.2-3).

2.2.1.3 Condition based or predictive maintenance

Condition based maintenance attempts to perform maintenance only when the asset requires it. Condition based maintenance require continuous monitoring of equipment and use the information to decide whether to stop the machinery and do maintenance or not (Singh and Pycraft 1997:712). Basically, predictive maintenance differs from preventive maintenance by basing maintenance need on the actual condition of the machine rather than on some preset schedule.

Some of the advantages of predictive maintenance are that it eliminates catastrophic equipment failures and minimize costs and inventory. Predictive maintenance can optimize the operation of the equipment, saving energy cost and increasing plant reliability. Past studies have estimated that a properly functioning predictive maintenance program can provide a savings of 8% to 12% over a program utilizing preventive maintenance alone. Depending on a facility's reliance on reactive maintenance and material condition, it could easily recognize savings opportunities exceeding 30% to 40% (Sullivan *et al*., 2004:5.3-4).

The challenge to predictive maintenance is that the implementation of the whole program is very expensive. Condition monitoring equipment can be costly, and in addition to that is the training of in-plant personnel to effectively

utilize predictive maintenance technologies which will require considerable funding. Program development will require an understanding of predictive maintenance and a firm commitment to make the program work by all facility organizations and management (Sullivan *et al*., 2004:4).

2.2.1.4 Reliability Centered maintenance

Reliability centered maintenance (RCM) is based on the philosophy that maintenance is a key function of the company. It is crucial for the expected functional performance and productivity goals to be achieved. Therefore once production goals have been determine, RCM will identify maintenance requirement of a physical asset that meet the operational or production goals, then it optimizes the performance, with real results (Campbell, 1995:105).

RCM recognizes that all equipment in a facility is not of equal importance to either the process or facility safety. It recognizes that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others. It also approaches the structuring of a maintenance program recognizing that a facility does not have unlimited financial and personnel resources and that the use of both needs to be prioritized and optimized (Sullivan *et al*., 2004:5.4-5).

In a nutshell, RCM is a systematic approach to evaluate a facility's equipment and resources to best mate the two and result in a high degree of facility reliability and cost-effectiveness. RCM is highly reliant on predictive maintenance but also recognizes that maintenance activities on equipment that is inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach (Sullivan *et al*., 2004:5.5.).

2.2.2 Understanding Operations Failures

The choice of maintenance approach depends on the understanding of the equipment or process possible failures. O'Connor (2002:1) defines failure as the termination of an item's ability to perform a required function. In any operations there is always a chance that in the process of making the product

or providing the service, things might go wrong. It is very important that operations managers should accept that failure will occur, and attempt should be made to minimize the failures. Organization needs to prioritize the failures in terms of seriousness and pay particular attention to those which are critical to the rest of the operation (Singh and Pycraft, 1997:694).

Failure in an operation can occur because of number of reasons, namely:

- **Design failures**: The overall design of the operation could be the root cause of failure. The failures could occur because the circumstance under which the operation has to work was not expected. The design failures could be avoided by identifying the range of all circumstances under which the operation has to work and designing accordingly (Singh and Pycraft, 1997:695).
- **Overstressed**: If the stress applied exceeds the strength of the asset then failure will occur (O'Connor, 2002:5).
- **Wear and tear**: The asset might be strong at the start of its life but become weaker with age (O'Connor, 2002:6).
- **Staff failures**: People failures can come in two types: errors and violations. Errors are mistakes in judgment, which a person should have done something different and the result is some significant deviation from normal operation. Violations are acts which are clearly contrary to defined operating procedure (Singh and Pycraft, 1997:698).

2.2.2.1 Patterns of Failure

Campbell (1995:66) emphasizes that the key to select the correct maintenance is based on understanding how the failure happened, and how it can be prevented. Different equipment will follow a different pattern of failure. There are six known failure pattern, namely:

- **Worst old or Wear out Failures**: These failures are age-related, they normally increase rapidly at particular point of use. Routine maintenance based on time is very effective on worst old failures (Campbell, 1995:66).

- **Bathtub**: These failures are relatively high at the beginning and end of the asset life. The maintenance strategy must deal with early and end of life problems (Campbell, 1995:66).
- **Slow aging**: There is a steady increasing probability of failure with age. This type of failure is associated with continuous exposure to stress (Campbell, 1995:66).
- **Best new**: There are no failures when equipment is new, then failure becomes constant. Age-based routine maintenance is generally ineffective in these types of failures (Campbell, 1995:66).
- **Constant or Random**: These are random failures that are not age related. Age-based routine maintenance is generally ineffective in these types of failures (Campbell, 1995:66).
- **Worst New or Early Infant**: This is a most common failure in complex equipments. The probability of failure declines with age. Once the infant mortality problem is solved routine maintenance plays a minor role (Campbell, 1995:66).

The different failures can be represented in the Bath curve as shown in Figure 2.1. below

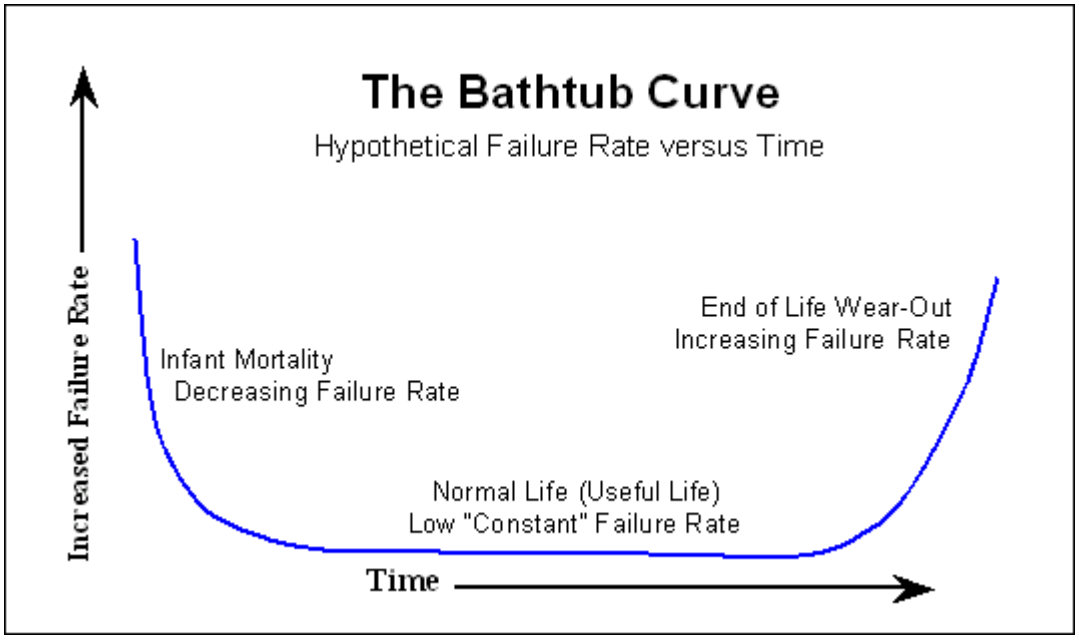

Figure 2.1 The Bathtub Curve (Wilkins, 2002:1)

2.2.2.2 Consequences of failures

A detailed analysis of any industry is likely to yield high number of failure modes. Each of these failures affects the organization in some way, but the effect is different (Moubray, 2001:10). They may affect operations, production quality, safety and environment. Some will take time and money to repair. It is these consequences which strongly influence the extent to which failures are prevented. This means if the failure has serious consequences, means must be put in place to avoid it (Moubray, 2001:10).

Moubray (2001:10) classifies the failure consequences to four groups

- **Hidden failures consequences**: It has no direct impact, but can expose the organization to multiple failures with serious, often catastrophic consequences (Moubray, 2001:10).
- **Safety and environmental consequences**: It can injure or kill personnel, or lead to environmental contraventions (Moubray, 2001:10).
- **Operational consequences**: It affects production with serious financial consequences (Moubray, 2001:11).
- **Non operational**: It doesn't affect production but only have direct cost of repair (Moubray, 2001:11).

The consequences analysis enables the organization to focus the on maintenance activities that have most effect on the performance of the organization. Failure management techniques can be divided into 2 categories (Moubray, 2001:11).

- **Proactive tasks**: These are tasks undertaken to prevent failures. Many people believe that the best way to improve plant availability is to do some kind of proactive maintenance in routine basis. This assumption is based on that most items operate reliably for certain period and then wear out (Moubray, 2001:11).
- **Default actions**: These are action taken after the failure mode is understood properly. It can be redesign (modifications change the capacity), run to failure (allow them to occur then fix them), fault finding

(checking hidden function periodically to determine whether they have failed) (Moubray, 2001:14).

2.2.3 The challenges of maintenance improvement

Welch (2007a:1) highlights that even if the failure patterns and consequences are well understood, there will always be challenges in maintenance improvement. The effective maintenance is the one that can bring effective improvement in the way maintenance is performed. According to Welch (2007c:1-3) the challenges to the maintenance improvement are as follows:

- **People**: The ability of the utility to perform maintenance at low costs lies on the available skilled maintenance people. Finding, training and retaining the skilled maintenance people is one of the top challenges facing maintenance organizations ((Welch, 2007c:1).
- **Maintenance Leadership**: Effective maintenance organizations needs leadership that is able to create an environment of change not commonly found in most maintenance teams (Welch, 2007c:1).
- **Tools and Technology**: Effective maintenance has changed significantly in recent years. Maintenance today is far more technology based than it is a repair activity with need for greater emphasis on predicting and forecasting maintenance needs. Now there is a great need to measure maintenance if improvement is required ((Welch, 2007c:1).
- **Processes**: Welch (2007c:1) argues that in maintenance, 85% of problems are process related and 15% are people related. Therefore there is a great need to focus the efforts on process improvement.
- **Costs**: Maintenance must be able to demonstrate a measurable return on investment, and must be able to justify its existence through reduction of machine downtime and reduced overtime. Maintenance excellence is the balance of performance risk and cost to achieve optimal solution (Welch, 2007c:2). Maintenance managers have a challenge to increase output, reduce downtime and lower the maintenance costs, and do it with less risk to safety and environment. Then maintenance will be effective if it mean all these factors (Campbell, 2002:1).

2.2.4 Maintenance options

To meet the maintenance requirements, the company can consider two specific options. The company can outsource the maintenance activities to the external provider (outsourcing) or choose to keep the capability in-house (insourcing). The pros and cons of the two approaches are discussed below.

2.3 OUTSOURCING

In the 1990's some management theorists, like Pralahad and Hamel, argued that the important factor in maintaining competitiveness was differentiating between core and non-core functions, and then transfer all the non-core functions to the specialist in that function. This was not a particularly new idea but it was certainly one whose time had come. Since then a number of companies have been created on the principle of outsourcing non-core functions (Heywood, 2001:29). Over the past decade, outsourcing some functions or processes that was traditionally performed in-house has become popular. The drive for greater efficiencies and cost reductions has forced many companies to increasingly specialize in a limited number of key areas. Outsourcing has progressed from involving only peripheral business activities towards encompassing more critical business activities that contributes to competitive advantage (Heywood, 2001:29).

Outsourcing often provokes contrasting reaction from a range of organizational stakeholders including business leaders, unions, employees, politicians and government. Many business leaders like Information Technology sector have long regarded outsourcing as a powerful vehicle to achieve performance improvements, whilst the unions regard outsourcing as another weapon used by powerful businesses to erode the terms and conditions of an already embattled employee. Many governments including South Africa have been employing outsourcing as means of reducing the scale of large public sector organizations and accessing the capabilities products and service providers in the private sectors (Mclvor, 2005:10). The disbursements of security grants in most countries (including South Africa) is outsourced to private companies like Cash Management Services

2.3.1 What Is Outsourcing?

Patel and Aran (2005:7) define outsourcing as the contractual service of transferring one or more business processes to a third party provider, where the latter takes over the management, ongoing support and infrastructure of the entire processes. When these processes are executed by vendors in a different country, it is known as offshore outsourcing or offshoring.

Outsourcing involves sourcing of goods and services previously produced internally with the sourcing company from external suppliers (Mclvor, 2005:2). This term is commonly used in relation to switching of supply of products or services to the external suppliers. But it can also involve transfer of an entire business function to a supplier.

Linder (2004:27) defines outsourcing as a means of purchasing services from an outside company that a company currently provides, or most organizations normally provide, for themselves.

Greaver (1999:3) defines outsourcing as an act of transferring some of an organizational recurring internal activities and decision rights to outside providers.

Outsourcing is when a firm hires an outside company to perform a specific task or function on behalf of the firm. The company works at the firm's direction, yet operates independently (Savarino, 2001:1).

Thomson and Strickland (2005:153) outlines the outsourcing strategies as a conscious decision to abandon attempts to perform certain function internally and instead to farm them out to outside specialist and business partners. The driving forces behind outsourcing are that outsiders can often perform certain activities better and cheaper, and outsourcing allows the firm to focus on its core businesses.

Atluri and Nalli, (2006:2) define outsourcing as assigning the internal work to an external service provider to reduce cost and also to get the work done more effectively and efficiently.

Brown (2005:20) defines outsourcing as a basic redefinition of corporation around core competencies and long term outside relationships. The core competencies and outside relationships are identified with objectives of bringing value to the end customer and ensure the highest productivity for the corporation.

Brown (2005:20-24) categorizes outsourcing to three levels, namely: tactical, strategic and transformational.
Tactical outsourcing occurs when the reason for outsourcing is tied to a specific problems being experienced by the firm. Often the firm is already in trouble and outsourcing is seen as direct way to address the problems e.g., lack of financial resources to make capital investments, poor management competency. Tactical outsourcing often accompanies large scale corporate restructuring. The aim is to:

- Generate immediate cost savings.
- Eliminates the needs for future investments.
- Realize the cash infusion from sales of assets.
- Relieve the burden of staffing.

Strategic outsourcing occurs when the business sought greater value from outsourcing relationships and focuses their energies on core businesses. According to Greaver (1999:8) the outsourcing initiative becomes strategic when it aligned with the organization's long term strategies.

Transformational Outsourcing uses outsourcing for the purpose of redefining the business. The company looks at the long-term survival of the company and decides to transform themselves and their markets to redefine the business world before it redefine them.

Despite the scale, outsourcing is not a straight forward financial or purchasing decision, in many cases it a major strategic decision that has an implication for the entire organization.

2.3.2 Driving forces of Outsourcing

The trend towards the increased used of outsourcing has been driven by a number of inter-related factors in the external business environment (Mclvor, 2005:10-17).

2.3.2.1 Globalization

Over the last few years the external business environment has become increasingly global for many industries (e.g. Information Technology industry). The relaxation of the trade barriers facilitated a move where the national markets are merging into a single global market. These changes have presented organizations with significant opportunities, and most companies have been in good position to achieve economies of scale, share the R&D and marketing across their various markets, and access lower costs labor sources (Mclvor, 2005:10).

The liberalization of international trade has allowed many countries to grow more quickly through exports. The export led growth has been central to the industrial policy of Asian countries like South Korea, China and Japan, which in turn has raised living standards in these countries. However liberalization of trade has also led to many job losses in developed economies like USA as companies increasingly outsource manufacturing and service related activities to developing economies with low labor costs. Outsourcing has become increasingly associated with globalization (Mclvor, 2005:11).

2.3.2.2 Developments in Information Technologies

Advances in telecommunications and Information Technology have facilitated the trend towards outsourcing. Information Technology (IT) has efficiencies in a number of business areas, ranging from design, marketing and finance. Furthermore IT is facilitating the ability of the organizations both globalize production and access new markets (Mclvor, 2005:14).

In the late 1980's General Electric executives went to India on business and discovered that India has a powerful brainpower. After this visit all the software production was moved to where there was an abundance of computer scientists. Again during the Y2K millennium bug, there was a fear that computers will shut down and cause a global crisis. America had thousands of computers for upgrade, and the workload forced them to outsource all the software upgrade to India. Immediately after Y2K, the dot com (e-commerce) bubble came up and demanded credible IT skills, and exploded the outsourcing relationship of India and America. Since then, there has be been a number of outsourcing opportunity between the two countries, e.g. call centre management (Friedman 2006:126-136).

2.3.2.3 Public Sector reforms

The trend towards increased outsourcing has also been influenced by wide ranging reforms in public sector organizations in many countries. Some governments believe that assets and activities should be transferred from public sector to the private sector in order to improve performance. The argument is that the public sector should aspire to levels of performance attainted in the private sector (Mclvor, 2005:15).

Traditional methods of road construction and maintenance delivery are increasingly are being replaced with more effective and efficient delivery mechanisms. Many governments around the world have embarked on a course of road authority reform with the objective of improving accountability and efficiency and reducing government involvement in service delivery. This reform can take many different shapes, and the nature of the reform depends to a very large extent on the conditions prevailing locally. The list of countries undertaking such reform is very long: Australia, Brazil, Canada, Colombia, Malaysia, Sweden, United Kingdom, Uruguay, and Zambia are but some of the countries (Horak *et al*., 2004:1).

Within South Africa, the National Department of Transport (NDoT) investigated various innovative ways to meet the need for new road construction and the increasing backlog in maintenance and rehabilitation. After the new National Transport Policy was accepted they embarked on a strategic commercialisation drive which culminated in the establishment of the South African National Roads Agency (SANRAL). At the other end of the scale, partnering for the Government also meant forging a new relationship with Civil Society. Road maintenance by contract was identified by the NDoT and its agent SANRAL, as an ideal area where small, medium and micro enterprise (SMME) emerging contractors can be empowered (development opportunity for previously disadvantaged individuals and groups). Such contracts have been put into place since 1998 on National Roads across South Africa (Horak *et al*., 2004:1).

2.3.2.4 More demanding customers

In many business sectors consumers have become more sophisticated and demanding as they become knowledgeable on issues such as price, reliability and availability (Mclvor, 2005:17). Access to technology like Internet has enabled the consumers to have an access to international products. One can shop around the world using the internet and get to compare the price with the local products. Outsourcing opportunities have given the local industries an opportunity to reduce their costs and compete effectively through outsourcing.

2.3.3 Why Outsourcing

According to Bragg (2006:2-5) a company will be more likely to outsource a function if there are multiple reasons. Bragg highlighted the following reasons:

- **Acquire new skills**: In a fast evolving market where new technologies are emerging, knowledge and skills of individuals are very limited. Not every company is able to attract the knowledge and skill base. When assessing the skills level, the company may find that the skill level is inadequate for a given function. This may results in minimal improvements to the function in the future. The company can solve this problem by handing over the

function to the outsourcing supplier who specializes in that function. This reason is most common to the function that requires high skill level such as engineering and computer services (Bragg, 2006:2). The growing shortage of maintenance skilled resources and the aging utility workforce influence businesses towards outsourcing. With many utilities outsourcing has shifted from primarily cost reduction to a combination of cost control and access to capital for technology investment and skills (Brock, 2009:3).

- **Acquire better management**: When the poor maintenance performance is attributed to poor management, outsourcing the maintenance function to the supplier to gain access to the best and most experience managers in a functional area is a viable option. Symptoms of poor management are high incidents of absenteeism, poor quality products and missed deadlines (Bragg, 2006:2).
- **Enhance controls**: Where the company management is concerned about its ability to provide sufficient control over its operations, some functions can be outsource to quality supplier whose operations can be readily certified. The large portion of pressure to maintain adequate controls could be alleviated.
- **Focus on strategy**: The company managers spend a lot of time handling the details of operations of their functional areas. By outsourcing a function while retaining the core management team, management team can focus on strategy related issues (Bragg, 2006:2).
- **Focus on core functions**: The Company can choose to focus their energies on core functions and distributes all other functions among a group of suppliers who are capable of performing them well enough. A company may even outsource the core functions that are becoming less important in the near future due to changes in nature of the business (Bragg, 2006:2).
- **Avoid measure investments**: A function that is not efficient due to lack of investment can be outsourced to prevent making huge investment. This can help the company to keep up with the latest technology, where suppliers use latest technology to drive the costs down (Bragg, 2006:3).

- **Assist a fast growth situation**: If the company is rapidly acquiring market share, there is a strong needs to build the company to handle the vastly increased volume of the business. In this situation the company may bring supplier that can take over a function so that management could focus its attention on a smaller number of core functions. This approach is useful when the supplier have pre-existing capacity to handle massive increase in transactional volume by the company (Bragg, 2006:3).
- **Handle overflow situation**: A company may find that there are times of the day or year an operation is overloaded for a reason that are beyond its control. It may be cost effective to retain the supplier to whom the excess work will be shunted when the in-house staff is unable to keep up with the demand. This is a reasonable alternative to an option of overstaffing the in house function in order to deal with the overflow that may occur on a small percentage of time (Bragg, 2006:3).
- **Improve flexibility**: When an operation experiences extremely large swing in work volume it may be easier to eliminates the fixed cost of an internal staff and move the function to the supplier who will be paid for the work done. This converts fixed costs into variable costs which will fluctuate directly with the transaction volume (Bragg, 2006:4).
- **Improve ratios**: Some companies will outsource to improve on performance ratios. When assets are transferred to the supplier, the return on asset will increase. Only the functions that are heavy in assets will have a significant improvement in asset ratios (Bragg, 2006:4).
- **Enhance credibility**: Small companies can use outsourcing as a marketing tool. It can use the services of best-known suppliers and imply that its functions are of highest quality because well-known supplier maintains them (Bragg, 2006:5).
- **Maintain old functions**: A company may find that its in house staff is unable to maintain the existing function while also shifting to the new technology. Outsourcing the old functions will allow the company to focus its effort on new technology while the supplier maintains the old functions (Bragg, 2006:5).

- **Reduce costs**: Cost savings can be achieved by outsourcing the function that will lower the costs. A cost saving is possible if the supplier take advantage of volume purchasing and economies of scale (Bragg, 2006:5).

2.3.4 Outsourcing Risks

While there are many good reasons to outsource a function, there are also a number of risks associated with outsourcing. Bragg (2006:8) highlighted the following risks.

- Transfer of knowledge to the outsourcing company can encourage new competitors (Cordon and Heikkila, 2002:183).
- Possibility of supplier failure can also lead to a company failure, especially in critical services such information technologies and engineering (Bragg, 2006:9).
- Outsourcing can lead to the development dependencies that create unforeseen strategic vulnerabilities (Insinga and Werle, 2000:1).
- **Loss of confident information**: There is a serious risk that critical information might be lost or stolen from the suppliers (Bragg, 2006:9).
- **Future change in supplier circumstances**: A supplier may have financial difficulties and that will affect the outsourcing relationship (Bragg, 2006:8).
- **Perceived risk lower than actual**: There is always a possibility that the outsourcing success could be exaggerated and management comes to wrong decision (Bragg, 2006:8).
- **Political fallout**: A serious risk of fall out with the community when local people are affected negatively by outsourcing (Bragg, 2006:9).
- **Local responsibility**: When the company carry the responsibility to the customers about the product that is produced by the supplier (Bragg, 2006:9).
- **Job Losses:** The person sponsoring outsourcing could loose the job if outsourcing fails (Bragg, 2006:10).
- Loss of capabilities when staff is transferred to the external supplier.
- Establishing effective governance for the relationship.
- **Management of transitions**: Poor implementation can lead to failure.

2.3.5 Outsourcing decision making

Conventional wisdom regarding the outsourcing decision states that you should outsource your non-core business activities. The difficulty with this approach, however, is that it provides no guidance for deciding which activities are non-core. Ultimately, in many organizations adopting this approach, the discussion about what is core and what is non-core ends up being highly subjective (Dunn, 2007:1). Cordon and Heikkila (2002:183) argue that classifying an activity as non-core may lead to serious oversimplification of the complexity of the real business situation. Cordon and Heikkila (2002:183) further recommends that one must understand the coordination of the firm's activities through its value chain.

2.3.5.1 Core Competencies

According to Greaver (1999:87), core competencies are the innovative combinations of knowledge, special skills, proprietary technologies, information and unique operating methods that provide the product that the customer value and want to buy. The competencies become core if it creates products and services that the customer sees as exceptionally different. Core competencies are what set the company products and services apart from the competitor's similar offerings.

Lynch (1997:258) suggests that there are three areas that distinguish major core competencies

- **Customer value**: Competence must make a real impact on how the customers perceive the organization and its products or services.
- **Competitor differentiation**: Competence must be competitively unique. If the whole industry has the skill, then it is not core unless the organization's skills in the area are real special.
- **Extendable**: Core skills need to be capable of providing the basis of products or services that go beyond those currently available. The organization needs to imagine how it might be exploited throughout its operations.

Welch (2007c:2) suggests that core competencies are only the activities that an organization must do with internal resources in order to create or maintain competitive advantage in the market place.

2.3.6 Outsourcing the Maintenance Function

The popularity of maintenance outsourcing in industrial markets continues to grow as competitive pressures and demand to do more with less have driven many companies to innovation to reduce costs. Rather than considering outsourcing their maintenance function as a means to rid themselves of a problem, management has learned that such an approach is a smart business move. Maintenance activities that once took a chunk of management and administrative time and effort are now shifted to the maintenance contractor, allowing plant management and other personnel to focus on operational and throughput issues. These companies have embraced the numerous advantages outsourcing their maintenance (whether totally or partially) brings by gaining access to world-class capabilities, a flexible resource base and shared risk (Wood, 2008:1).

However, before embarking on such a journey a serious consideration must be given to the impact outsourcing will have on the company and what it will accomplish. Focus should be given to the expected benefits, including cost savings, reallocation of internal resources in key operational areas and efficiency gains from a balanced, well-trained and experienced maintenance work force (Wood, 2008:1). According to Bragg (2006:273) it is common that transportation and moveable equipment, which can be easily moved to the supplier's central repair facility, are outsourced to the external company. The fixed and specialized equipment is mostly maintained in house, however the latest trends indicates a shift from to outsourcing even in fixed equipment. Large companies have setup workshop inside the factories that are completely run by external company.

2.3.6.1 How much maintenance to outsource

The most important consideration in maintenance outsourcing decision is what aspects of maintenance to outsource. If we considerer the maintenance management process as consists of six steps as shown below, then there are number of options (Dunn, 2007:1).

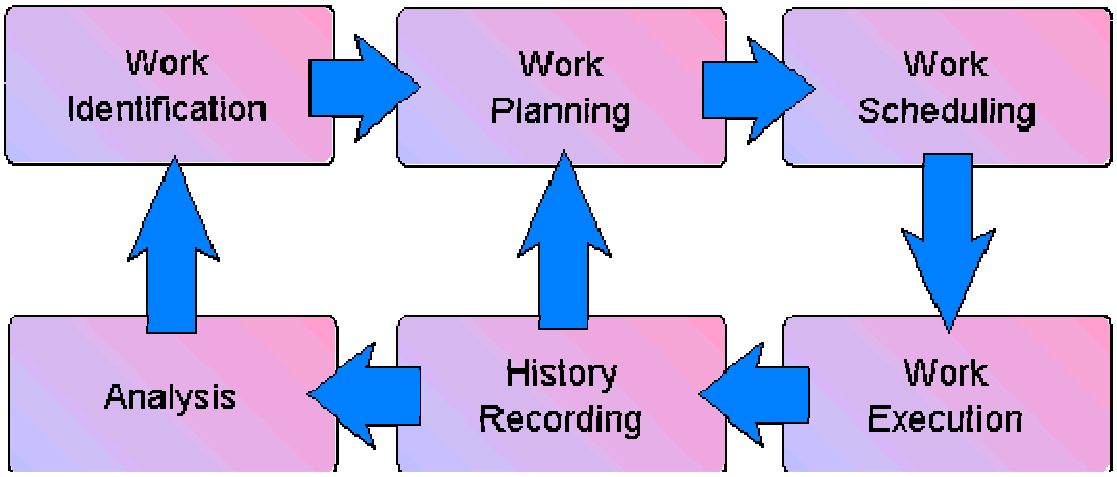

Figure 2.2 Maintenance Management Process (Dunn, 2007:1).

In the first instance, organizations may choose simply to outsource the work execution step, while retaining the remaining steps in-house. This is often done on a limited basis by employing contractors to supplement an in-house work force during times of high workload and during major shutdowns. This is the minimalist approach to outsourcing (Dunn, 2007:1).

An alternative approach is to outsource all of the above activities with the exception of the analysis and work identification steps. In this approach, the contractor is permitted to plan and schedule his own work, and decide how and when work is to be done, but the outsourcing organization retains control over what is to be done (Dunn, 2007:1). It is most unusual, however, to outsource the planning and scheduling function without this being part of a significant or complete maintenance function outsourcing. This usually remains in-house as a management function indicating its criticality in the total maintenance process (Francis, 2003:2).

A third approach is to outsource all of the above steps, thus giving control over the development of equipment maintenance strategies (i.e. Preventive

and Predictive Maintenance programs) to the contractor. In this instance, the contract must be structured around the achievement of desired outcomes in terms of equipment performance, with the contractor being given latitude to achieve this to the best of his ability (Dunn, 2007:1).

There are advantages and disadvantages to each approach, and the most appropriate approach will depend on the client's particular situation. The outsourcing decision must also be specific on what type of maintenance will be outsourced. The Kuwait utility (Alshibani and Sharaf, 2007:1) chose to outsource all the preventative and breakdown maintenance, and kept predictive maintenance and RCM in house. Where the outsourcing is driven by fluctuating workload other strategy applied is shown in Figure 2.3

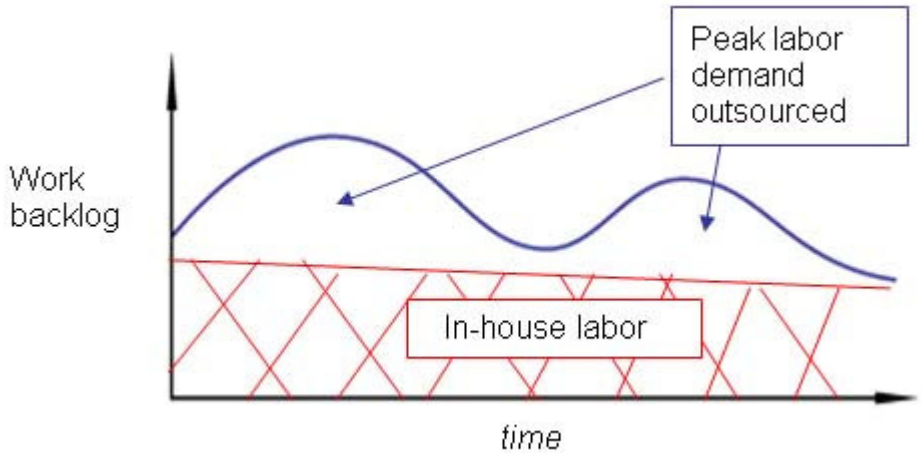

Figure 2.3 Workload driven outsourcing (Phelan, 2006:5)

A core, in-house staff of skilled labor is retained to execute the base load of work expected to be done year after year. Peak years (or seasons) of labor demand for specific initiatives, like replacing major substation assets, will require relying on outside service providers. The challenge of implementing the above strategy is deciding what activities should be outsourced and how to peel that activity out of the organization's existing way of doing business (Phelan, 2006:5).

One approach is to outsource activities to a provider that has a particular expertise in a limited activity. An original equipment manufacturer will do a better job in installing or maintaining the equipment it supplies. Injecting such subject matter expertise can provide the desired productivity improvements through reducing overall installation time and start-up failures or introducing low-cost diagnostic technologies (Phelan, 2006:5).

Before developing a work specification to outsource an activity, it's important to develop a process description with a clear understanding of the various internal departments that are involved (directly or indirectly) in that process. Without mapping its existing process, a utility runs the risk of its outsourcing partner not satisfying all the various departments' requirements (Phelan, 2006:5).

2.3.6.2 Challenges of outsourcing maintenance function

Bragg (2006:274) highlighted the following as shortcoming for outsourcing maintenance function.

- The response time can be a challenge, especially where the supplier are located away from the companies premises. Dispersion of the supplier's key maintenance staff away from the efficient central facility. This will affect the response time (Bragg, 2006:275).
- Supplier may have minimal experience in maintaining more specialized equipment. Most industries are continuously investing in the new technology and that require the outsourcing company to keep up with technology (Bragg, 2006:275).
- Supplier may be reluctant to takeover specialized equipment if it doesn't market them to other companies. The outsourcing company will not spend money on training unless it brings good investment in the long term (Bragg, 2006:275).
- Supplier may be unwilling to stock spare parts for specialized equipment that cannot be used for other customers (Bragg, 2006:275).

- If the company charges fixed fee basis, there is an incentive to use the cheapest parts to repair the equipment. This will lead to more frequent equipment breakdowns (Bragg, 2006:275).
- Most suppliers are more than willing to take the new work on common equipment for which their employees already have expertise. There are cases where the equipment is likely to be used throughout the industry, the supplier will go out of their way to take the maintenance work and train their staff in the new maintenance techniques (Bragg, 2006:275).

2.3.7 Outsourcing Trends

Historically outsourcing was used when the company could not perform due to incompetence, lack of capacity, financial pressures or technological failure. Now outsourcing is being used to restructure companies that have been unsuccessful. The trend in large organizations is to outsource the entire processes. The suppliers will have to be large and sophisticated operations that provide added value that has never been seen before (Patel and Aran, 2005:12-13). This is known as Business Process Outsourcing.

According to the 2000 Outsourcing index, outsourcing has grown from a controversial practice to a business strategy. Internationally companies are increasingly focusing on the marketing of their brand, not the product, with the product merely being a marketing tool. Companies like Coca-Cola are therefore moving away from making a product to developing a brand with the view that anyone can manufacture a product. As a result companies are bypassing production completely, closing the existing factories and outsourcing the manufacturing of the products, mostly offshore, to the contractors and subcontractors whose only concern is filing the order (Esselaar, 2003:47).

Globalization, increasing competition and falling transport costs are resulting in multinational companies outsourcing to regions with the lowest manufacturing costs, bringing with them advanced production techniques to take advantage of lowest costs. A Singapore electronics manufacturer,

Flextronics acts as a contract producer for Microsoft, Motorola, Dell, Palm and Sony Erricson (Esselaar, 2003:48).

Internationally, outsourcing is usually associated with developed countries outsourcing to less developed, low wage, low cost countries. Internationally outsourcing usually take place offshore with outsourcing that does take place domestically mostly associated with highly skilled industries such as information technology. The result is a reduction in demand for low-skilled workers in the outsourced countries. In contrast, the majority of outsourcing in South Africa occurs within the country, and domestic outsourcing is concentrated in unskilled and semi-skilled areas of work (Esselaar, 2003:48).

Since the early 90's, outsourcing has migrated from being a trend to a way of life for most industries. Companies' skills haven't been devalued but rather redefined to better fit corporate business models. Reduced headcounts are essential for a lean organization, and the business model requires a focus on core competencies and a shift away from hands-on approach. The balancing act that the companies must master is outsourcing nonessential jobs while retaining the personnel and talent necessary for innovation. Put another way, organizations would like to have their cake and eat it, too (Higgins, 2007:33).

2.3.8 Outsourcing from South African Perspectives

Outsourcing has become a growing business practice both internationally as well as in South Africa. The literature suggests that South Africa is moving in the same direction as the rest of the world, toward greater use of flexible workers such as contract temporal and casual workers. This is collaborated by a number of small scale surveys that have identified an expansion of outsourcing, subcontracting and other form of typical work (Esselaar, 2003:46).

2.3.9 Criticisms of Outsourcing

There is a conflict between an economic rationale for greater flexibility, and a social rationale demanding living wages and certain degree of job security. Labour protection is centered around the universal notion of employment

relationship, while practices like outsourcing, employment has become far more versatile thus affecting the structure of the employment. The critics of outsourcing argue that firms outsource not because they have to, but they are driven by reducing costs through cutting labour. The main criticism of outsourcing is that the practice results in a casualisation of labour, and reduces employment, lower the wages and benefits received by workers (Esselaar, 2003:33).

Outsourcing also results in a worsening of working conditions for workers. Contract workers provided by an intermediary often work longer hours than core workers, with short notice periods and are not entitled to lunch breaks and paid maternity leaves. Furthermore when these workers lose their jobs or retrenched, they do not receive severance packages (Esselaar, 2003:35).

Outsourced, subcontracted and part-time workers are usually difficult to unionize. Contract workers move around very often to different site work, therefore it becomes difficult for the trade union organizers to visit them. In addition, because their employment is mostly temporary, they have to be extremely careful that they satisfy the labour broker or contractor. This is exacerbated by the fact that there is competition for employment among the unemployed workers (Esselaar, 2003:40).

2.3.10 Outsourcing and Human Resource Challenges

According to Gamble (2007:SR6) successful firms are under pressure due to the high need for services, and therefore staffing becomes a real challenges. The challenge is how to win the talent wars as competition to recruit and retain top performers gets tough. While the organization may turn to outsourcers to fill gaps in its own staff, they may discover that the outsourcer suffer the same quality and retention problems. It is hard to find a company to do some of the services at required competency level (HR Focus, 2007:S3). However, it is true that collaboration with other organization results in synergies and leveraged resources (Garen, 2007:SR4).

The Surepayroll Pay Index and Surepayroll Hiring Index in America is used to measure the salary and the hiring trends of the small businesses. The 2006 results showed a downward trend in hiring and upward trend in salaries. Small businesses were experiencing high costs associated with salaries. As a result small businesses started outsourcing certain non-core activities instead of hiring full-time employees. Some companies were using college intern to get a basic tasks done for very little costs (Janis, 2006:52).

2.4 INSOURCING

But what happens when outsourcing does not work for the company? What happens when the costs go up, or the level of service goes down or both? What happens when outsourcing becomes the problem and not the solution? It is easy to go along with the crowd, but it is crucial to consider the costs of going along for a ride (Chapman and Andrade, 1998:56). Often businesses attempt to pull up their socks by going outsourcing and unfortunately in doing so strangle the contractor (Francis, 2003:6). Before a company can jumps into outsourcing, it needs to be sure that it can jump back. It is a fact that not all organization had positive experiences when deciding to outsource maintenance work. Some maintenance work outsourcing have been noted to be of poor quality, lengthy time of delivery, inexperience contractor, high overall costs and monitoring issue. The dissatisfactions always lead to reverse outsourcing which is known as insourcing.

The development of maintenance as an outsourced activity grew rapidly in the 1990's, Railtrack (National Train Company in UK) was one of the major organizations to adopt this policy in full. However this approach was widely criticized by the British communities, especially after a number of high profile maintenance related accidents. The government then decided to form Network Rail as a replacement for Railtrack. Within few months, Network Rail decided to take back all the maintenance that was outsourced by Railtrack. In recent years the rail industry is not alone in driving outsourcing policy for maintenance then reversing – there are also examples in the electricity and water sector (Levery, 2004:39)

In the late 80's, British Columbia, transferred all highway maintenance to private contractors and eliminated most of its transportation resources. In the following years it was reported that there has been an overall cost increase, and that the contractors were spending less effort on long term preservation efforts than required. It was also reported that there was less competition in the process of renewing contracts. The Canadian Ministry of Transport then decided to shift to performance based contracts that are randomly audited and rewarded for high performance (Bell and Dlesk, 2006:7).

Although outsourcing policy has brought so many changes in different industries, however it can be taken too far. Some companies are now outsourcing the majority or even all the critical activities, but they will soon find the serious drawback to this strategy. In the event where outsourcing doesn't bring any positive results, insourcing is an option.

2.4.1 What Is Insourcing

Chapman and Andrade (1998:56) defined insourcing as the return of previously outsourced function back to the company.

2.4.2 Insourcing Benefits

Heaton (2004:94-96) highlighted the benefits that have been achieved by companies through insourcing.

- **Control:** The first and the most obvious benefit to insourcing is the control a company has over the activities. Outsourcing by its nature leaves the company at the mercy of their suppliers. While there are steps a company can take to ensure some accountability from its supplier base, they can be never be as effective as retaining these functions internally. Even if every supplier delivers on time and executes perfectly, a system can still be hung up by one or two suppliers that did not (Heaton, 2004:95).

- **Cost advantages**: Suppliers are in business to make profit. While the specialization theoretically allows them to give service at less cost, they are also adding a profit margin to improve their bottom line. Insourcing allows

much greater control of costs that could have been excessive when service is outsourced. The streamlined communication advantage made possible by insourcing offers cost advantage that may not be visible at first glance. When engineers, designers and technicians are working in a close environment, opportunity arises to devise and incorporate simple changes to a part that improve efficiency and lower the costs (Heaton, 2004: 95).

- **Availability**: As the companies ramp up the production the availability of capacity becomes essential. When supplier resources are strained, priority becomes an issue. Unless you are one of the major players, doing volume business with that particular supplier can lead to longer lead time. The longer lead time can have a negative consequence to your production (Heaton, 2004:95).
- **Unique Insight:** Insourcing brings an advantage of employee's unique insight into a project or the agency goals (Heaton 2004:96).

2.4.3 Trends in Insourcing

McCue (2006:1) argue that even though outsourcing is regarded as the solution in cost reduction, but insourcing will continue to emerge as new trend as business seek to reverse bad outsourcing decisions and regain more control over IT costs and operations. Some IT chiefs believes that even if one can have a good outsourcing service level agreements, change control and contracts, but insourcing gives them the flexibility to change direction very quickly, without a consensus being reached in some cases, and at known risk. This approach has paid dividends they need (McCue, 2006:1).

Bill (2005:1) states that although companies are nervous about hiring full timers, they are investing big time in IT skills. The research suggests that the companies are avoiding the risks of outsourcing by bringing the work back in–house. Projects have more predictable results even if costs increase.

Outsourcing by its nature leaves the companies at the mercy of their suppliers. While there are certain steps a company can take to ensure some accountability from its supplier base, they can never be as effective as

retaining these functions internally. Insourcing offers the greatest assurance of quality control (Heaton, 2004: 95)

In analysis of IPG Photonics, a laser firm Dahl (2006:49) states that there is an overwhelming trend in business today toward sending more production out of house. But many companies are finding it difficult to manage outsourcing, particularly when dealing with suppliers in far-flung countries like China and India. After factoring in headaches such as long lead times and poor quality control, some businesses are deciding that it's just not worth it. The rise in counterfeiting is also making high-tech manufacturers worry of handing over intellectual property to foreign vendors. There is a growing number of manufacturers who have decided to keep their secret sauce at home (Dahl, 2006:49).

2.5 MEASURING AND BENCHMARKING PERFORMANCE

Management expert Tom Peters believe that what get measured it gets done. But what is measured and how is done are critical decisions (Campbell, 1995:75). Performance management is one of the basic requirements of the effective operation. Measurement is important in maintenance continuous improvement and in identifying and resolving conflicting priorities (Campbell, 2001:37-38).

Campbell (2001:38) uses the process approach to analyze and define the measurement factors that can be used in performance measurement. Figure 2.4 shows the 3 major elements of this equation: the inputs, the outputs and the conversion process.

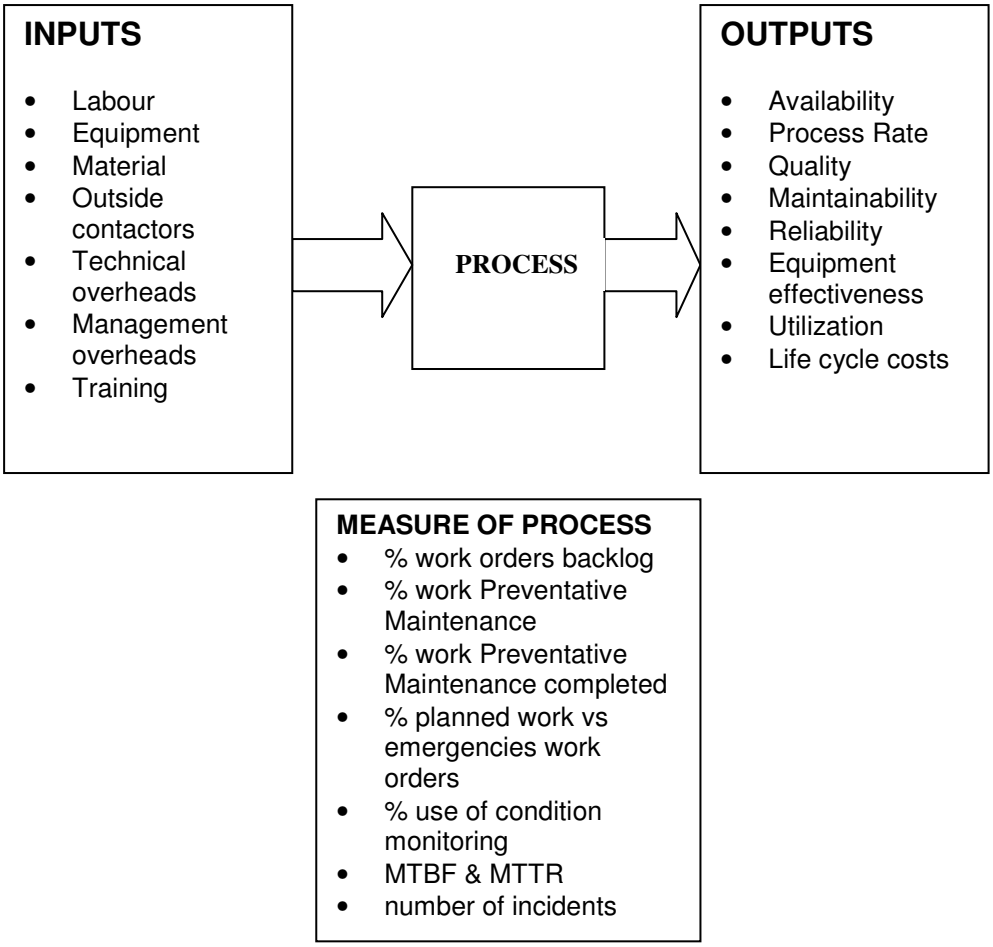

Figure 2.4 Maintenance as business process (Campbell, 2001:39)

One can look at maintenance as a business process that turn the inputs into useable outputs. Most of the input are readily measured such as labor costs, materials, equipment and contractors, but some are difficult to measure accurately and that includes experience, techniques, teamwork and work history yet each can have significant impact in the results (Campbell, 2001:39).

Likewise, some outputs are easy to measure and others are harder but very significant to overall maintenance performance. The task of maintenance department is to convert the maintenance inputs into required outputs. Because it not feasible to come up with the absolute conversion rate,

benchmarking process is used by senior management as key indicator of good maintenance management (Campbell, 2001:40).

2.5.1 Maintenance Performance Measures

According to Campbell business approach to maintenance, a good combination of inputs must give the desired outputs. The desired output in maintenance is better equipment performance. Therefore the measures on the outputs will highlight the effect of the inputs on the outputs. The measures can be divided into equipment performance measures, costs performance measures and process performance measures (Campbell, 2001:76).

2.5.1.1 Equipment performance measures

There are many ways in which one can measure the effectiveness of an asset is fulfilling its functions. Moubray (2001:293) and O'Connor (2004:8) highlighted the most common ones as follows

Reliability: The ability of an item to perform a required function under stated conditions for stated period of time (O'Connor, 2004:1). A primary component of reliability analysis is referred to as failure rate, or the number of failures expected during a certain period of time. Calculation of equipment failure rate and its inverse –The Mean Time Between Failures (MTBF) for items which are repairable or Mean Time to Failures (MTTF) for non-repairable items is the basic of reliability predication (O'Connor, 2004:8).

$$\text{Failure rate} = \frac{\text{Number of failures}}{\text{Operating time}}$$

The Mean Time Between Failures (MTBF) is the expected time between two successive failures of the system (O'Connor, 2004:8).

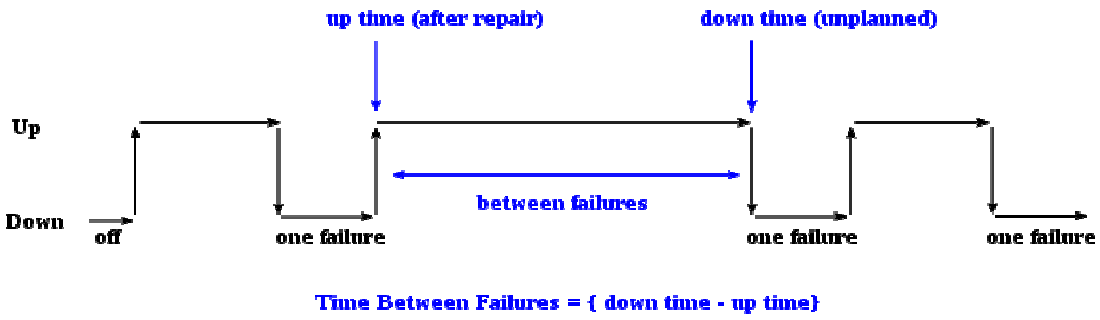

Figure 2.5 Illustration of Mean Time Between Failures (wilkipedia)

The Mean Time to Failures (MTTF) is the expected time to failure of a non-repairable system (O'Connor 2004:8).

Maintainability: Campbell (1995:76) defines maintainability as the measure of ability to make equipment available after it has failed, or mean time to repair (MTTR). It is determine by:

$$\text{MTTR} = \frac{\text{Total downtime from failures}}{\text{Number of failures}}$$

The Mean Time to Repair (MTTR) is the expected time to recover a system from a failure. This may include the time it takes to diagnose the problem, the time it takes to get a repair technician onsite, and the time it takes to physically repair the system (Torell and Avelar, 2004:6). Similar to MTBF, MTTR is represented in units of hours.

Availability: It is the degree to which the operation is ready to work. An operation is not available if it has either failed or being repaired following a failure (Singh and Pycraft, 1997:698). Availability can be calculated as follows:

$$\text{Availability} = \frac{\text{MTBF}}{(\text{MTBF} + \text{MTTR})}$$

where MTTR = mean time to repair (Torell and Avelar, 2004:6)

Therefore MTBF impacts both reliability and availability. It is very clear that availability improvements can be achieved by improving the MTBF and/or MTTR (O'Connor, 2004:15). Availability is determined by a system's reliability, as well as its recovery time when a failure does occur. Availability is often looked at because, when a failure does occur, the critical variable now becomes how quickly the system can be recovered (Torell and Avelar, 2004:5).

MTTR impacts availability and not reliability. The longer the MTTR, the worse off a system is. Simply put, if it takes longer to recover a system from a failure, the system is going to have a lower availability. The availability equation illustrates how both MTBF and MTTR impact the overall availability of a system. As the MTBF goes up, availability goes up. As the MTTR goes up, availability goes down (Torell and Avelar, 2004:6). MTBF and MTTR do convey frequency of repair, and length of repair time.

According to Campbell (1995:76) availability is a measure of uptime, as well as the duration of downtime. It can be calculated as:

$$\text{Availability} = \frac{(\text{Schedule time} - \text{All unplanned delays})}{\text{Schedule time}}$$

$$\text{Downtime} = \frac{(\text{Unplanned delays})}{\text{Schedule time}}$$

The value of any of these measures has a lot to do with how the equipment is designed and built. The best test of equipment performance is often its performance trend over time. This will provide a good feedback and highlight changes in operating and maintenance practices (Campbell, 1995:77).

2.5.1.2 Costs performance measures

According to Campbell (2001:39) maintenance management is a business process as shown in figure 2.4, the maintenance costs are inputs into the

process, and that means they can influence the outputs. Maintenance costs accrue in the following categories (Campbell, 1995:78)

- Labor costs covers wages and benefits of people directly involved in maintenance.
- Materials including all parts, components, consumables and others used by maintenance.
- Services covers all workshops, stores warehousing, engineering and any other facilities supporting maintenance.
- Outside services covers all contracted services (maintenance, training and consultants).
- Technical support including supervision, planning, material coordination and data entry.
- Overhead covers all other support functions that are not directly involved with maintenance but provide that is vital in maintenance business.

2.5.1.3 Process performance measures

Maintenance management is a business process with costs as inputs, equipment performance as outputs. In between the inputs and outputs there is a complex process of making sure the desired output is achieved (Campbell, 1995:78). The measures of the process can be any of the following:

- **Planned versus unplanned work**: Unplanned work can be very costly, therefore there should be very little unplanned work in the effective maintenance management.
- **Emergencies**: Any immediate situation that affect safety, profitability or customer value, and that necessitate overtime is a true emergency. The impact and the costs of emergency can be measured.

The outsourcing client will use some of these of performance measurements to see if the suppliers are performing properly (Bragg, 2006:296). According to Welch (2007a:2), one cannot achieve maintenance improvement, unless performance measurements are in place. Welch (2007a:2) further

emphasizes that maintenance should not be outsourced to the service provider who cannot demonstrate a history of collecting maintenance data and reporting metrics for continuous improvement. To ensure a continuous adherence to the agreed performance, performance measurements must be put in place.

2.6 TRAINING AND DEVELOPMENT

While the organization may turn to outsourcers to fill gaps in its own staff, they may discover that the outsourcer suffer the same quality and retention problems. It is hard to find a company to do some of the services at required competency level (HR Focus, 2007:S3). However, it is true that collaboration with other organization results in synergies and leveraged resources (Garen, 2007:SR4). Whether outsourcing or insourcing, these challenges are normally addressed by aggressive training and development programs.

In general organization's training and development practices are its intention efforts to improve current and future performance by helping employees acquire the skills, knowledge and attitudes required of a competitive work-force (Jackson and Schuler, 2000:350).

2.6.1 Training

According to Jackson and Schuler (2000:350) training is defined as improving competencies needed to day or very soon. The main objective of training is to improve performance in a specific job by increasing employee's skills and knowledge. New hires may have insufficient skills and acquire training before being placed in a job. For other employees, technological changes and job redesign may create the need for new job skills. Another reason that employees may need new skills or knowledge is that they have been transferred or promoted (Jackson and Schuler, 2000:350).

2.6.2 Development

Jackson and Schuler (2000:350) define development as activities intended to improve competencies over a longer period of time. The objective of

development is to prepare the workforce for roles they might have in future. While development activities may improve performance in one's current job, but the approach is that employees must be given a stretch assignments. The expectation is that employees may have a great deal of valuable learning which will be useful in the future (Jackson and Schuler, 2000:350).

2.6.3 Strategic importance of Training and Development

According to Jackson and Schuler (2000:352) best competitors are using training and development practices to improve the ability of the workforce to implement their overall strategy.

2.6.3.1 Improving performance

A major purpose of training is to enhance the ability of employees to perform their jobs at peak levels. In high competitive industries, training for immediate performance improvement is particularly important to organizations with stagnant or declining rate of productivity or customer satisfaction. Training for performance improvement is also important to organizations that are rapidly incorporating new technologies and, consequently increase the likelihood of employee obsolescence.

2.6.4 Determining Training and Development needs

Training is offered on the basis of need, to rectify skill deficiencies, to provide employees with job-specific competencies, to prepare employees for future roles. Although training and development can serve other purposes, a formal need assessment is vital part of the training system. The four components of the needs assessment process are as follows:

Organizational needs Analysis involves analyzing organization wide performance criteria and uncovers problem areas that may indicate the need for training (Grobler *et al*., 1996:312). It begins with assessment of the short and long term strategy and strategic business objectives of the company. The organizational need analysis should result in the development of clear statement of the goals that should be achieved training and development activities. It should also assess the organization's current climate for training.

A supportive training climate improves the chances that employees will successfully transfer what they learn from training programs to the job. Organizational need analysis should identify the available resources and any constrains that need to be considered when designing T& D programs and activities (Jackson and Schuler, 2000:357).

Job Need Analysis: involves an attempt to determine how the job should be performed (desired performance level) (Grobler *et al.*,1996:312).

Person Need Analysis: focuses on the individual employee and is used to identify employees for training. The output of this analysis is who currently needs T&D and what skills, knowledge, abilities or attitudes need to be acquired or strengthened (Grobler *et al.*,1996:312).

2.7 ATTITUDES

Lou Holtz the football coach said "Ability is what you are capable of doing. Motivation determines what you do. Attitude determines how well you do it." (Maxwell,1993:1). Training of employees alone cannot deliver good maintenance output, but the maintenance team with a good attitude will move mountains.

Maxwell (1993:20) defines attitude as an inward feeling expressed by behavior. That is the why an attitude can be seen without a word being said. According to Maxwell (1993:26) the important of attitude are as following

- Attitudes determines the approach to life
- Our attitude determine our relationship with people
- Often our attitude is the difference between success and failure
- Our attitude at the beginning of the task will affect its outcome more than anything.

Kreitner and Kinicki (2005:160) define attitude as a learned disposition to respond in a consistently favorable or unfavorable manner with respect to the

given object. The attitudes consists of three components namely Affective, Cognitive and Behavioral.

- Affective Component of an attitude contains the feelings or emotions one has about a given object or situation.
- Cognitive Component of an attitude reflects the beliefs or ideas one has about an object or situation.
- Behavioral Component refers to how one intends or expects to act toward someone or something.

In organizations attitudes are important because they affect job behavior. If the employees believe that the managers are in conspiracy to make employees work harder for the same or less money, then it is important to know how these attitudes were formed, their relationship to actual job behavior, and how they might be changed (Robbins, 2005:70).

2.7.1 Types of Attitude

A person can have thousands of attitudes, but organizational behavior focuses our attention on a very limited number of work related attitudes. These work-related attitudes tap positive and negatives evaluations that employees hold about aspects of their work environment. Most researches in organizational behavior are concerned with three attitudes: job satisfaction, job involvement and organizational commitment (Robbins, 2005:78).

2.7.1.1 Organizational Commitment

Organizational Commitment reflects the extent to which employee identifies with particular organization and its goals, and wishes to maintain membership in the organization. Organization commitment is an important work attitude because committed individuals are expected to display a willingness to work harder to achieve organizational goals and greater desire to stay employed in the organization (Kreitner and Kinicki, 2007:166). There appears to be a positive relationship between organizational commitment and job productivity. A number studies have demonstrate the individual level of organizational commitment is a better indicator of turnover (Robbins, 2005:79).

2.7.1.2 Job Involvement

Job Involvement measures the degree to which person identified psychologically with her or his job, and considers his or her perceived performance level of important to self-worth. Employees with a high level of job involvement strongly identified with the kind of work they do. A high level of job involvement is positively related to organizational citizenship and job performance. In addition high job involvement has been found to be related to fewer absences and lower resignation rates (Robbins, 2005:78).

2.7.1.3 Job Satisfaction

Job Satisfaction refers to the collection of feelings that an individual hold towards his or her job. A person with high level of job satisfaction holds positives feelings about the job, while a person who is dissatisfied with his or her job hold negatives feelings about the job. When people speak of employee attitudes, more often they mean job satisfaction (Robbins, 2005:78).

Managers' interest in job satisfaction tends to center on its effects on employee performance. As a result a number of studies have been designed to assess the impact of job satisfaction on employees' productivity, absenteeism, turnover and citizenship.

- **Satisfaction and productivity**: Studies have shown that organizations with more satisfied employees tend to be more effective than organizations with fewer satisfied employees. Although we might not be convinced that a happy worker is more productive, but it is true that happy organizations are more productive (Robbins, 2005:86).

- **Satisfaction and Absenteeism**: Studies shows a consistent negative relationship between satisfaction and absenteeism. It certainly makes sense that dissatisfied employees are more likely to miss the work (Robbins, 2005:87). Managers are advised to look at improving job satisfaction for improvement in absenteeism.

- **Satisfaction and Turnover**: Turnover is important to mangers because it both disrupt organizational continuity and is very costly. Costs of turnover can be categorized into separation costs and replacement costs. Satisfaction is also negatively related to turnover, therefore manager are advised to reduce employee turnover by increasing job satisfaction.

- **Satisfaction and Citizenship**: Organizational citizenship behaviors consist of employee behaviors that are beyond the call of the duty (Kreitner and Kinicki, 2007:174. Satisfied employees would seem more likely to talk positively about organization, help others, and go beyond the normal expectations in their job. Studies have shown that satisfaction influences organizational citizenship behavior through perception of fairness (Robbins, 2005:88). When ones perceive organizational processes and outcomes to be fair, trust is developed. The higher the trust, the more likelihood of employee engaging in behaviors that goes beyond the formal job requirements.

2.8 CONCLUSIONS

Maintenance has been a core in-house activity, however, globalisation and development in technology has changed the way companies view core activities such maintenance. It is now being viewed by many organizations as a non-core business function, and outsourcing of the maintenance function has become an increasingly widespread practice. Maintenance outsourcing is defined as assigning the maintenance function to an external service provider to reduce cost and also to get the work done more effectively and efficiently.

Outsourcing have its own sets of challenges, and some of them are late project crisis, poor quality spares, increased costs, loss of skills, and drop in service levels. In the event where outsourcing doesn't bring any positive results, insourcing is an option. Before a company can jumps into outsourcing, it needs to be sure that it can jump back. Insourcing is an exciting idea because the company has the knowledge and experience of all the mistakes

learned from previous function which led to outsourcing, along with the lesson learned from outsourcing.

In this chapter the literature review on maintenance and outsourcing concepts are discussed. Firstly the theory of maintenance and its philosophies is explored. The second part of this chapter covered the outsourcing and insourcing concepts and its drivers. The third part covered the key performance measures of maintenance function. The fourth part covered how training and development can support maintenance function. The last part of this chapter covered the role of the attitude in an organization.

The research design and methodology is presented in the next chapter (chapter 3).

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter was to present the research design and research methods chosen to answer the research questions. The aim of this research was to analyze and compare the maintenance performance during maintenance outsourcing and insourcing period (1998-2008) in Transmission East Grid. In addition the research also evaluated the sustainability of an ongoing maintenance insourcing. The key objective of maintenance activities is to maximize the availability and reliability of the assets and equipment to produce the desired quantity of products, within the required quality specifications, in a timely manner. Obviously, this objective must be attained in a cost-effective way and in accordance with environmental and safety regulations (Pintelon and Parodi-Herz, 2008:22).

Rosaler (2004:12-4) highlighted that in order to apply best maintenance practices one must have measures of ones progress and success. As Doctor Juran, a leading quality expert said that if you measure it, you will manage it and improve it (Rosaler, 2004:12-4). The overall success of equipment reliability strategy requires knowledge of equipment performance and conditions, training, focus on right goals, teamwork, communication and leadership (Rosaler, 2004:12-4). The capacity to sustain effective maintenance is determined by maintenance staff competency, attitude and good training and development.

3.2 RESEARCH DESIGN

Research is a systematic process of collecting, analyzing and interpreting data in order to increase an understanding of the phenomenon concerned. The research process is systematic in that defining the objective, managing the data, and communicating the findings occur within established frameworks and in accordance with existing guidelines (Leedy & Ormrod, 2005:2). There are two common approaches in conducting a research, and these are quantitative and qualitative methods.

WorldiQ.com (2010:1) defines quantitative research as the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect. In general quantitative research is used to answer questions about relationships among the measured variables with the process of explaining, predicting and controlling (Leedy & Ormrod, 2005:94). Quantitative research usually starts with hypothesis to be tested, and then variables are selected for study. The data of the chosen variables are collected, analyze and conclusion is drawn on data. Social surveys and experiments are frequently viewed as prime examples of quantitative research and are evaluated against the strengths and weaknesses of statistical, quantitative research methods and analysis (Williams, 2007:66).

There are three broad classifications of quantitative research: descriptive experimental and causal comparative (Leedy and Ormrod, 2005:179, 217).

Descriptive research: The descriptive research approach is a basic research method that examines the situation, as it exists in its current state. Descriptive research involves identification of attributes of a particular phenomenon based on an observational basis, or the exploration of correlation between two or more phenomena (Williams, 2007:66).

Experimental research: The essence of experimental research is to determine if a cause-effect relationship exists between one factor or set of factors, the independent variable(s) and a second factor or set of factors, the dependent variable(s) (Ellis and Levy, 2009:326). During the experimental research, the researcher investigates the treatment of an intervention into the study group and then measures the outcomes of the treatment (Williams, 2007:66).

Causal comparative research: In the causal comparative research, the researcher examines how the independent variables are affected by the dependent variables and involves cause and effect relationships between the variables (Williams, 2007:66). Unlike an experiment, the researcher does not take control of and manipulate the independent variable in causal-comparative research but rather observes, measures, and compares the

performance on the dependent variable or variables of subjects in naturally-occurring groupings based on the independent variable (Ellis and Levy, 2009:326).

Qualitative research is a type of scientific research that seeks to answer the research questions by systematically collects evidence, produces findings that were not determined in advance and produces findings that are applicable beyond the immediate boundaries of the study. Qualitative research begins with general research questions, and then the data is collected and organize in some form to give a meaning. Qualitative research always ends with the hypothesis or the theory arising from the data interpretation (Leedy & Ormrod, 2005:94).

3.2.1 Choice of Research Methods

3.2.1.1 **Descriptive research**

The maintenance performance analysis during outsourcing and insourcing periods was studied using quantitative research approach. According to Pintelon and Parodi-Herz (2008:22) the key objective of maintenance activities is to maximize the availability and reliability of the assets, and this objective must be achieved in a cost effective manner. The availability and reliability study or analysis normally uses quantitative data, therefore the choice of research variables for quantitative research was equipment availability, equipment reliability and maintenance costs.

The research employed the internal secondary data from the maintenance database for analysis. The secondary data is the data that was gathered by someone else (researcher, institutions, NGO's etc) for specific purpose (McCaston 2005:1). Even though the secondary data can be raw, but it is through reviewing, interpreting and cross-analyzing that these pieces of information give a better understanding of the situation (McCaston 2005:1). The secondary data is generally less expensive than the primary data, and its collection is quicker (Steppingstones 2004:1). The quality of information sources is determined by the original purpose of data collection, the credentials of the sources, its intended audience and its references.

The secondary data was acquired within the organization (Eskom) databases, and that made the acquisition less expensive and less time consuming. Eskom keeps records of all the equipment failure incidents, maintenance activities and maintenance costs pertaining to the network. These databases are updated daily, and get audited on certain interval to ensure the integrity of data that is used to make critical decisions. The Eskom Databases relevant to this study is shown in Table 3.1.

Database	**Variable data stored**
TIPPS (performance database)	• Equipment failures with dates, time, outage duration and failure root cause. • Interruption of supply with dates, time, outage duration and root cause. • Line faults with dates, time, outage duration and failure root cause.
SAP (financial database)	• Costs of all activities (breakdown, contracts, normal maintenance)
Phoenix (Maintenance database)	• Equipment maintenance history • Defects records • Outage records

Table 3.1 List of Eskom Databases

The maintenance performance analysis only focused on the two high voltage equipments, and that was circuit breakers and transformers. The reasons for this choice were that the circuit breakers and transformers are the most expensive equipments in transmission systems, and they contributes the highest in maintenance costs (Rush, 2005:5). The circuit breakers and isolators maintenance was brought in-house in 2003 and the transformer

maintenance remained outsourced with the Rotek Engineering, and therefore it made sense to look at the two equipments. Both equipments have moving part which requires routine maintenance intervention to keep it in good working condition. These were some of the influences to focus the study on circuit breakers and transformers performance.

This research used the 11 years maintenance performance data for circuit breakers (1998-2008) and 10 years maintenance performance data of transformers (1999 to 2008) to analyse the effectiveness of maintenance intervention at Eskom Transmission (East Grid). The main aim of the research was to analyze and compare the circuit breaker performance during outsourcing period from January 1998 to September 2003 and insourcing period from October 2003 to December 2008. In addition to the circuit breaker analysis, the aim of the transformer analysis was to evaluate the effectiveness of the transformer maintenance that was performed by Rotek. The transformer maintenance at the time of this study was still outsourced to Rotek Engineering.

The breakdown of key performance measures (variables) that were chosen for this research was as follows:

- Reliability measures: Failure rate and Mean time before failure (MTBF).
- Availability: Availability is a function of Mean Time Between failure and Maintainability which is Mean time to repair (MTTR).
- Maintenance costs.

The circuit breaker and transformer failures and maintenance history data were downloaded from TIPPS and Phoenix databases and saved in Microsoft Excel spreadsheet for further analysis. The data was used to analyse the availability and reliability of the circuit breaker and transformer between January 1998 and December 2008. The maintenance costs download from SAP provided all the expenditure for outsourced maintenance for the same period. The circuit breakers and transformers data is shown in Appendix A

and B. The calculation sample for reliability and availability is shown in Appendix C.

3.2.1.2 Survey research

The second part of the research was to answer the question of the sustainability of maintenance insourcing. The isolator and circuit breaker maintenance insourcing was implemented in September 2003, and the five years after the decision was implemented can give a good indication on whether the insourcing will continue to be effective and sustainable in the Eskom business. The sustainability of maintenance insourcing was studied using quantitative research. Rosaler (2004:12-4) highlighted that the overall success of equipment reliability strategy requires knowledge of equipment performance and conditions, training, focus on right goals, teamwork, communication and leadership. Therefore capacity to sustain the good equipment reliability requires competent staff, with right attitude and good training and development.

The maintenance efforts are sustainable if the following is met:

- Maintenance team is properly trained.
- Maintenance teams are given opportunities to apply their knowledge.
- There is enough technical and leadership support where needed.
- Maintenance teams believe they are adding value.
- Maintenance team believe they are compensated properly for their effort.

Therefore this part of the research attempted to answer the following questions:

- Are the employees getting relevant training and assistant to do the maintenance work effectively?
- How is the attitude and perception of employees towards outsourcing or insourcing?

The survey research was adopted to conduct the research on sustainability of maintenance insourcing. Gray (2004:99) defines a survey as a detailed and

quantified description of a population, a precise map or a precise measurement of potential. It involves the systematic collection of data, whether by interview questionnaire or observation methods. Precise samples are selected for surveying, and attempts are made to standardized and eliminate errors from the survey data gathering tools .

A detailed survey was conducted on maintenance staff to test their capabilities and attitude towards insourcing of maintenance. The survey was conducted using a standard questionnaire for the whole sample. The participating members were asked to respond to the set of questions in a predetermined order, and within a specific time. No names were written in the questionnaire. A clear instruction on completing the questionnaire was given on the front page to boost the response rate. Questionnaires was easier to complete and more appealing to the respondents. There is a tendency that the staff will not tell the truth when doing the face to face interviews, and most of them still feel that they will be victimised if they say something negative. Therefore a questionnaire was appropriate in this regard.

The design of the questions and the possible answers were based on the information obtained through the literature review. The questionnaires were reviewed by two supervisors prior to the survey to ensure validity of the instrument, and correct structure of the instrument and content. The questionnaire guide was divided into three parts. Parts one was the questions about effectiveness of training, part two was the attitude of employees towards the maintenance work and part three was the attitude towards outsourcing.

3.2.1.2.1 Sampling

The survey targeted the staff members who were part the 2003 maintenance insourcing project. The maintenance staff is located at 4 strategically located depots, namely Newcastle, Pinetown, Ladysmith and Empangeni depots. The data sample includes all equipment specialists from each depot who have

been around since 2003, and this amount to 15 participants. This covered the whole population of maintenance specialists in Transmission East Grid. The work that was previously outsourced is now done by these specialists under supervision of depot supervisor.

3.2.1.2.2 Reliability and Validity Considerations

Reliability and validity are two important components that affect the quality of measurements. Reliability is concerned with obtaining consistent, stable research results with replication that is when the study is repeated. It indicates whether the results obtained will be the same at different time and provide the way to assess the trustworthiness of the findings (Leedy & Ormrod, 2005:93). Validity is concerned with the accuracy. It refers to the degree to which measurement devices assess what is designed to measure (Leedy & Ormrod, 2005:92).

The reliability of the questionnaire is an ability of a questionnaire to give the same results when filled out by like-minded people in the same circumstances. The validity of the questionnaire is the degree to which the questionnaire is collecting the data intended to collect. The following steps were taken to increase reliability and validity.

- The wording of the questions were carefully examined to ensure all questions are fully and clearly written.
- The questions were designed to have a consistent meaning to all the respondents. Questions were simple and unambiguous.
- Each question was constructed to ask one question at any one time.
- More categories were used on the ordinal scale so that the respondents could have wider selection, thus giving answer of higher precision.

3.2.1.2.3 Methods of data collection

The questionnaire was adopted an instrument for survey data collection. The challenges of geographically constraints were resolved through the use of questionnaire. The survey questionnaires for qualitative data with a cover letter were sent by electronic mail to the respondents. The respondents were asked to print, complete and fax the questionnaire to the central office. The use of anonymous questionnaire was used to encourage more people to participate in the study. Some of the reasons for using a questionnaire were that the questionnaire is less intrusive and the respondent is not influenced by answering the question since no verbal and visual communication.

3.3 CONCLUSION

Research is a systematic process of collecting, analyzing and interpreting data in order to increase an understanding of the phenomenon concerned. In this chapter the theoretical concepts on quantitative and qualitative research are outlined, and the design and structure of this research were also explained. The research methods used in this research was quantitative research. The first part of the research which dealt with maintenance performance analysis used the internal secondary data acquired from Eskom in-house databases to answer the research questions. The second component of the research used the survey research establish the sustainability of maintenance insourcing in Eskom Transmission. The data collection technique made achieved by using questionnaires.

The results and interpretation of the research are presented in the next chapter (chapter four).

CHAPTER 4: RESULTS AND INTERPRETATION

4.1 INTRODUCTION

This chapter presents and examines the results of the equipment performance analysis and survey that was conducted in this study. The aim of this study was to analyse and compare the equipment performance during maintenance outsourcing (1998-2003) and maintenance insourcing period (2004-2008). The maintenance of high voltage equipment in Transmission Division was outsourced to Rotek Engineering from 1992. In October 2003 the decision was taken to use the in house staff for all the circuit breakers and isolators' maintenance.

The chapter is subdivided into three sections, which correspond to the three area of study: equipment performance analysis, maintenance costs analysis and maintenance sustainability survey. The equipment performance analysis and the sustainability of the in-house maintenance were studied using the quantitative research approach. The secondary data from Eskom maintenance database was used in equipment performance analysis. The key performance indicators (KPI's) that were chosen for maintenance effectiveness study were the maintenance costs, equipment availability, reliability and maintainability. The survey research was conducted to assess the sustainability of maintenance insourcing.

4.2 ANALYSIS OF EQUIPMENT PERFORMANCE

The equipment performance analysis only covered the circuit breakers and transformers. Like any other piece of plant, if maintenance is not done properly the equipment will fail in service. The consequences of failure can be catastrophic, and often results in interruption of supply over extended period (Singh and Pycraft, 1997:711). Therefore adequate maintenance is required for high equipment availability.

4.2.1 Circuit Breakers performance analysis

4.2.1.1 Circuit Breakers Reliability analysis

The breakdown of the circuit breaker failures from 1998 to 2008 is shown in Figure 4.1.

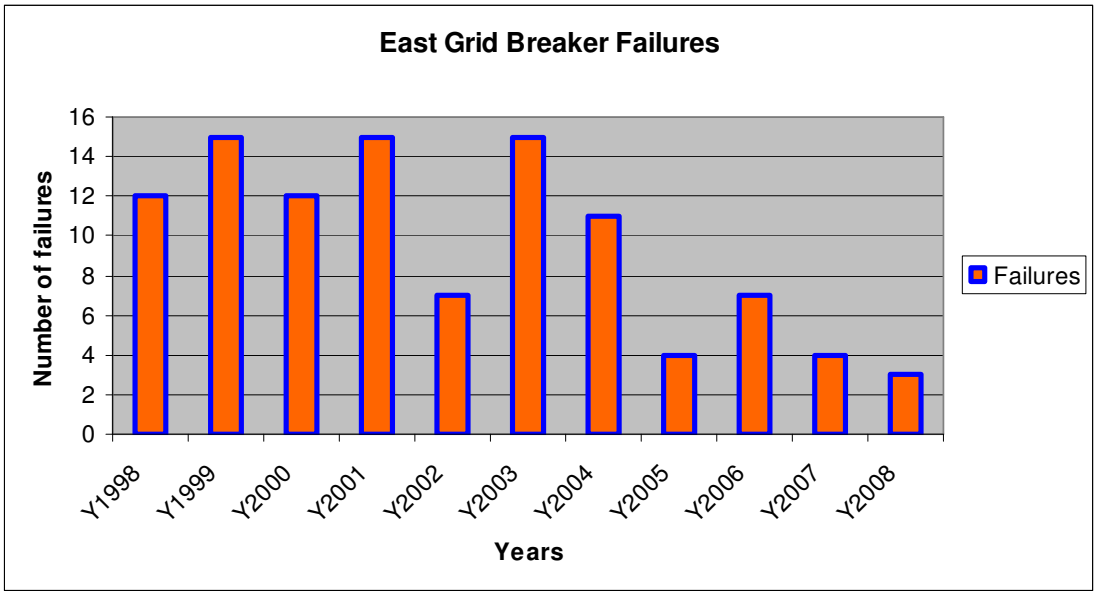

Figure 4.1: Circuit Breaker failures (TIPPS Database 1998-2008)

The total number of circuit breaker failures in the East Grid during 1998-2008 period was 105, and 76 (72%) of the 105 failures occurred from 1998 to 2003. The circuit breakers failures averaged at 13 failures per year between 1998 and 2003, and the average circuit breaker failures dropped to 6 failures per year between 2004 and 2008. There was a sharp decrease in circuit breaker incidents from 2003 to 2008.

The total number of installed circuit breakers that was used for reliability analysis was 429. The failure rate or probability of circuit breakers from 1998 to 2008 is shown in Figure 4.2..

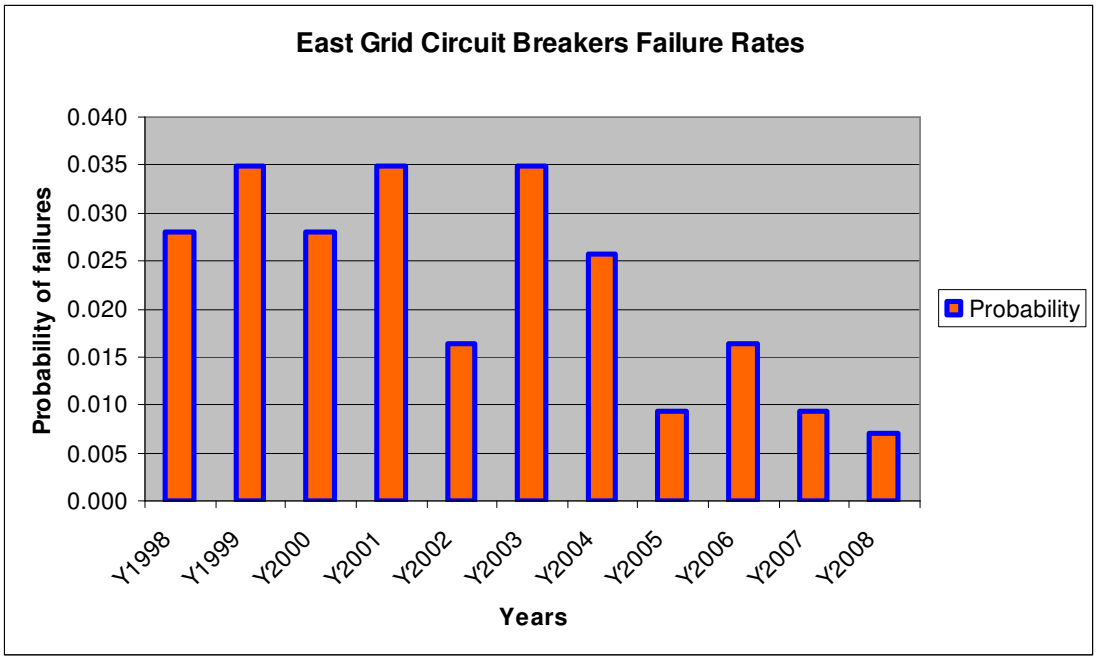

Figure 4.2 Failure rates (Reliability) of Circuit Breakers (TIPPS Database 1998-2008)

The failure rate oscillated between 0.029 and 0.035 during 1998–2003 period, except the 0.016 in 2002. The failure rate started declining sharply from 2004 (0,025) to 2008 (0.017). If the 11 year period is sectionalised to 3 year intervals, the failure rate is as follows:

- The failure rate was 0.03 (13 failures per year) in the first 3 years (1998-2000).
- The failure rate was 0.029 (12 failures per year) in the next 3 years (2001-2003).
- The failure rate was 0.017 (7 failures per year) in the next 3 years (2004-2006).
- The failure rate was 0.008 (3 failures per year) in the last 2 years (2007-2008).

The circuit breakers failure rate dropped by 77% in the 11 years period (1998-2008). The 75% failure rate drop happened in the last 5 years (2004 – 2008). The mean time before failures (MTBF) (inverse of failure rate) results of circuit breakers from 1998 to 2008 is shown in Figure 4.3.

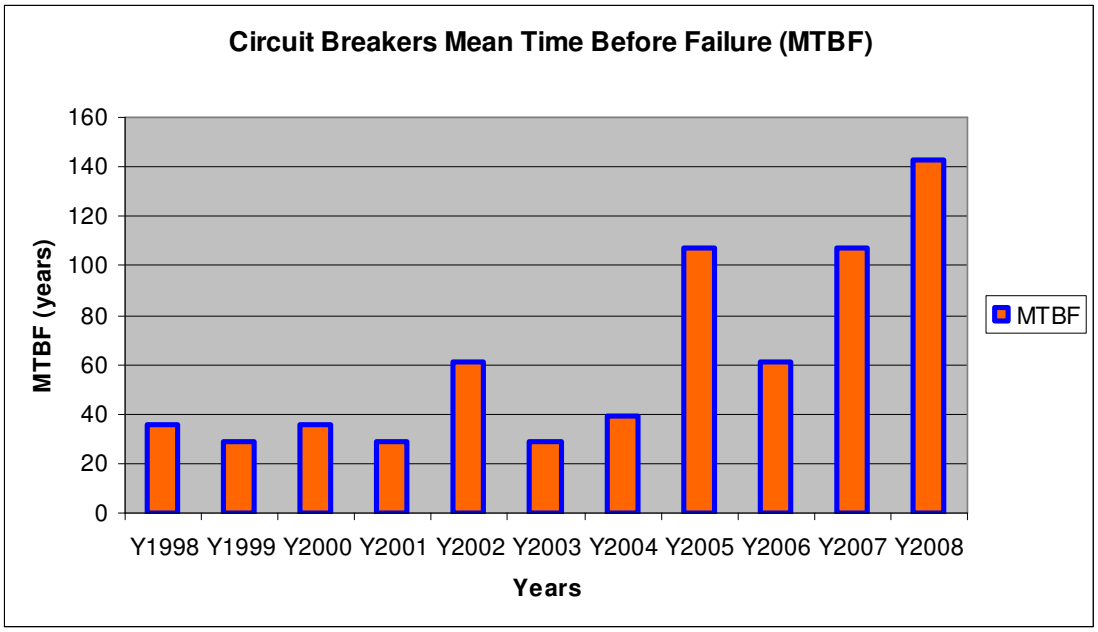

Figure 4.3 Mean time before failures (MTBF) of Circuit Breakers (TIPPS Database 1998-2008)

The failure rates in the first 6 years (1998-2003) oscillated the Mean Time Between Failures (MTBF) between a minimum of 28 years and maximum of 35 years (excluding 60 years in 2002). Then there was an upward trend of Mean Time Between Failures (MTBF) of circuit breakers from 2003 to 2008 caused by the declining circuit breaker incidents. In 2007 and 2008 the Mean Time Between Failures (MTBF) was above 100 years which is the highest in this 11 year study.

The objective of any maintenance intervention is to reduce failures or forced outages, and hence improving the Mean Time Between Failures (MTBF) which is a measure of equipment reliability.

4.2.1.2 Maintainability Analysis of Circuit Breakers

Maintainability provides a measure of the reparability of a system when it fails. The Mean Time to Repair (MTTR) is the expected time to recover a system from a failure (Torell and Avelar, 2004:6). The total outage time for all the circuit breaker incidents divided by the failures is the Mean Time To Repair of circuit breakers. The Mean Time To Repair (MTTR) trend of circuit breakers from 1998 to 2008 in Eskom East Grid is shown in Figure 4.4.

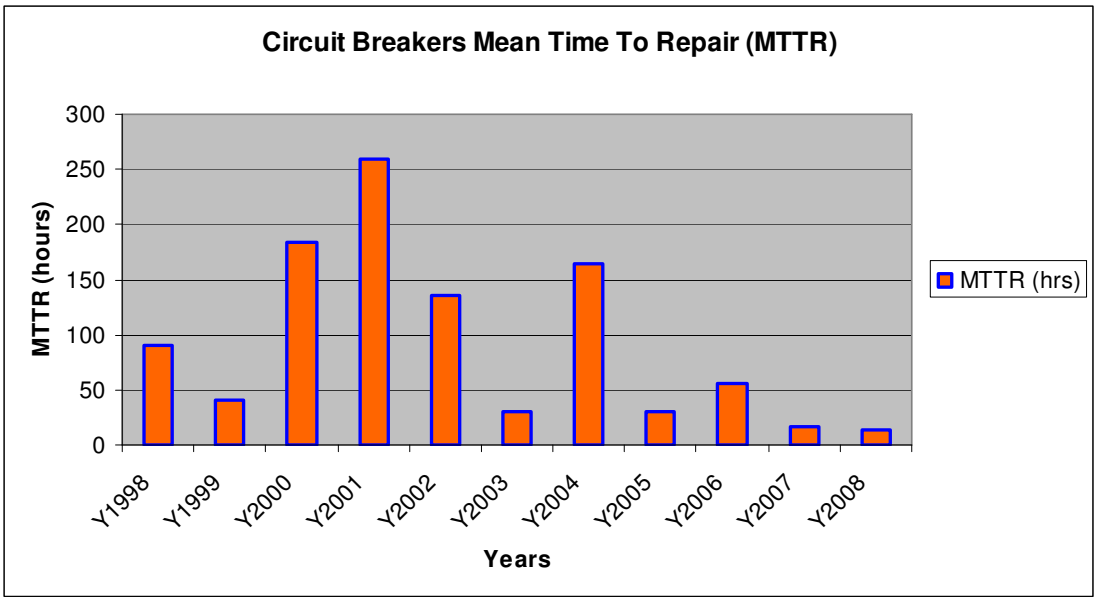

Figure 4.4 Mean Time to repair (MTTR) for circuit breakers (TIPPS Database 1998-2008)

The recovery time per failure (MTTR) showed an increasing trend from 1999 to 2001. The MTTR was 90 hours (3.75days) in 1998, 41 hours (1.7 days) in 1999, 184 hours (7.67 days) in 2000 and 260 hours (10.83 days) in 2001. Then it starts declining in the next 2 years to 135 hours (5.6 days) in 2002 and 30 hours (1.25 days) in 2003. There was a surge of 164 hours (6.8 days) in 2004 is followed 30 hours (1.25 days) in 2005, 56 hours (2.3 days) in 2006, 16 hours in 2007 and 14 hours in 2008. The MTTR was kept below 56 hours in the last 4 years which is the best result in the 11 year period. The high number of failures from 2000 to 2002 was also taking longer to be repaired. The average MTTR during 1998-2003 period was 123.3 hours, and during 2004-2008 period the average MTTR dropped to 38.8 hours. There was an improvement of 68.5% in recovery of the circuit breakers.

4.2.1.3 Circuit Breakers Availability analysis

Availability is determined by a system's reliability, as well as its recovery time when a failure does occur. Availability is often looked at because, when a failure does occur, the critical variable now becomes how quickly the system

can be recovered (Torell and Avelar, 2004:5). Figure 4.4 showed the availability analysis of circuit breakers from 1998 to 2008 in Eskom East Grid.

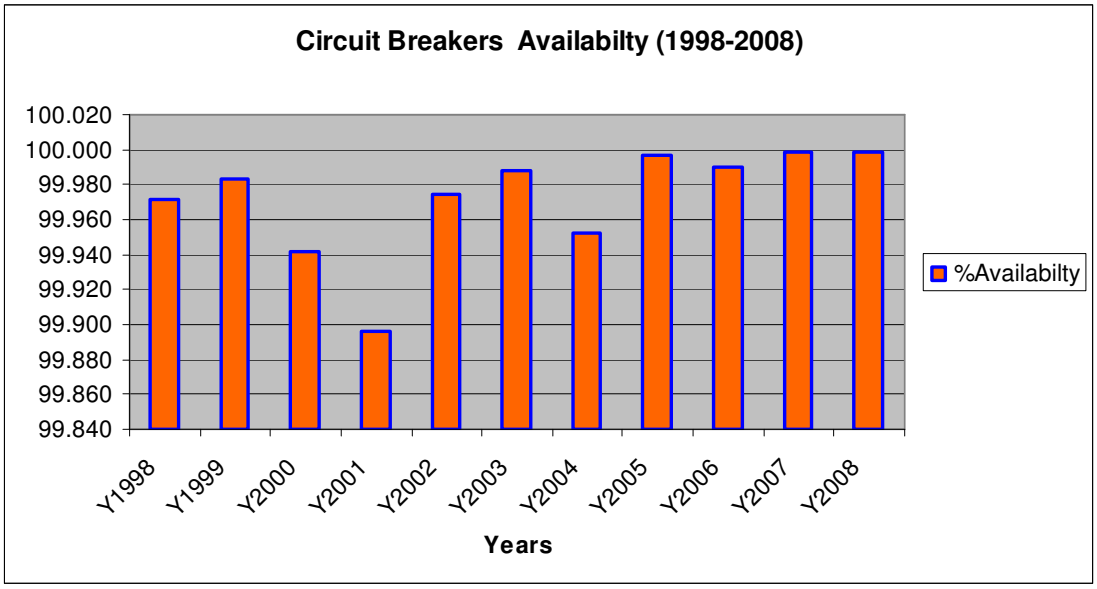

Figure 4.5 Availability of circuit breakers (TIPPS Database 1998-2008)

The circuit breakers availability analysis in Figure 4.5 showed a downward trend in availability from 1999 to 2001. The circuit breaker availability during this period drop from 99.984% in 1999 to 99.896% in 2001. This was due to low Mean Time Between Failure (MTBF) and high Mean Time to Repair (MTTR) during this period. In the next 2 years the circuit breaker availability went up again to 99.995% in 2002 and 99.988% in 2003, and it dropped to 99.952% in 2004. In the last 4 years the circuit breakers availability was the highest in the 11 years period, with lowest of 99.990% in 2006 and the highest of 99.999% in 2008. The improvement in Mean Time Between Failures and Mean Time To Failure in the last 4 improve the availability of circuit breakers.

4.2.2 Transformer performance analysis

The tapchanger is the only moving part of the transformer, and when it operates it makes and breaks the current under load condition. Therefore tapchanger maintenance is the only major maintenance done on transformers (Comark, 2007:7). Due to the complexity of the tapchanger switches, the scope of work and the required specialised maintenance tools, the

transformer tapchanger maintenance at the time of this study was outsourced to Rotek Engineering. The Eskom staff only performed the first line maintenance which is routine inspection, oil samples and all the transformer tests after maintenance completion.

4.2.2.1 Transformer Reliability analysis

The transformer incidents in the TIPPS database are categorized into severe and non severe failures. The severe failures are all major internal failures that can lead to longer transformer outage due to major repairs or replacements. The non-severe failures are minor incidents that are initiated by transformer accessories and results in a transformer trip. The common non severe failure is water ingress in the terminals causing the transformer trips. The non-severe failures normally have shorter outage duration and minor repairs (Comark, 2007:5). The transformers non-severe failures during 1999-2008 period is shown in Figure 4.6.

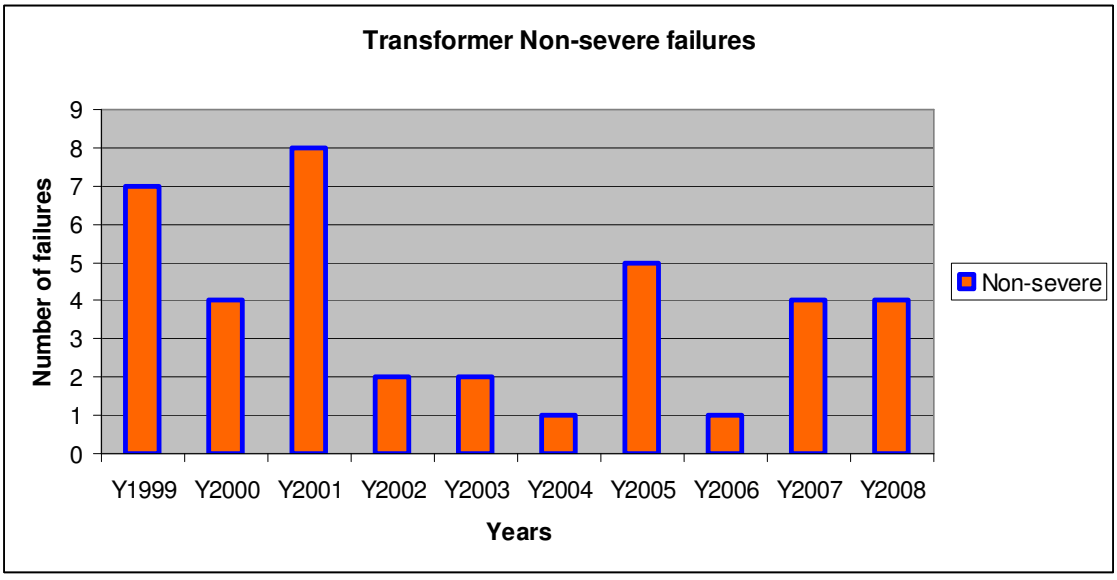

Figure 4.6 Non Severe Transformer failures (TIPPS Database 2008)

The non severe failures were averaged at 6 failures per year in the first 3 years (1999-2001), and then it came down to less than 2 failures per year between 2002 and 2004 and end at less than 4 failures per year between 2005 and 2008. Although these type of failures do trip the transformers, but the impact does not have serious consequences.

The transformer severe failures are critical failures which must be avoided at all times, they can be very expensive and can cause major disruption in the electrical network (Comark, 2007:5). The transformer severe failures during 1999-2008 period is shown Figure 4.7.

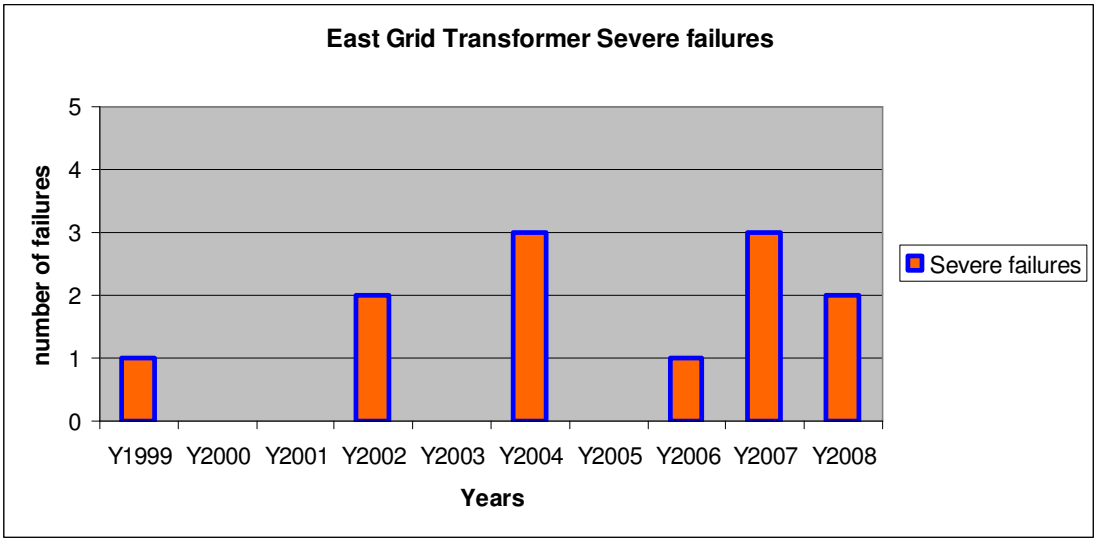

Figure 4.7 Severe Transformer failures (TIPPS Database 1998-2008)

According to Figure 4.7, East Grid had 12 severe transformer failures during 1999-2008 period, and this translate to an average of more than one failure per year. The last 3 years (2006-2008) shared 6 severe transformer incidents. The severe failure means the transformer will be out of service for extended period for repairs or replacement. The repairs can be done on site or at Rotek workshop.

Both severe and non-severe failures result in a transformer trip, and thus affecting the reliability of the transformers. The transformers failure rates (severe and non-severe) of the 69 transformers during 1999-2008 period is shown in Figure 4.8.

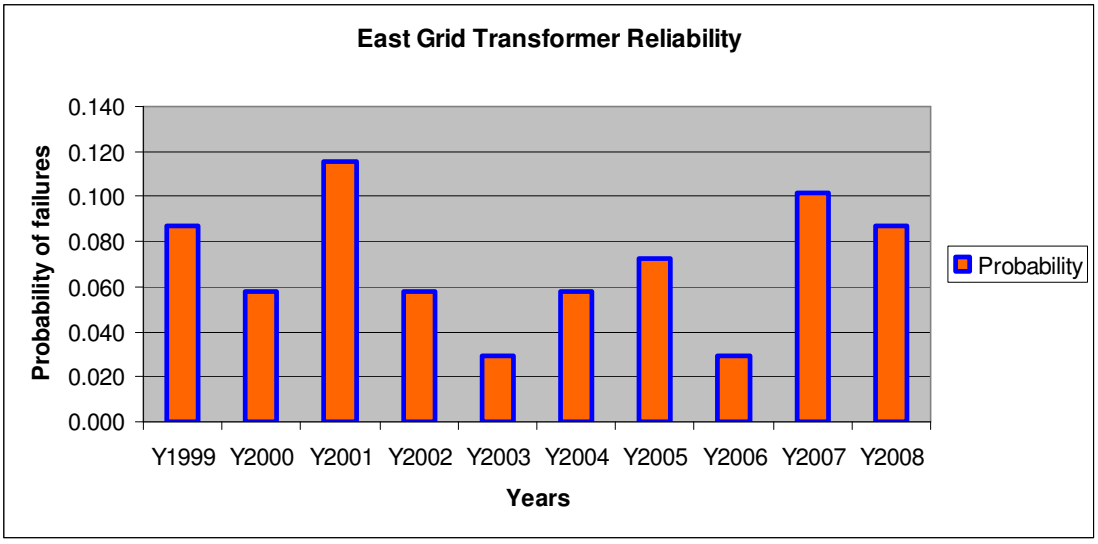

Figure 4.8 Transformer Failure rates (TIPPS Database 1998-2008)

The transformer failure rates in Figure 4.8 are very much random, with no sustainable trend. The average transformer failure rate over 10 years is 0.072 per year, and that translate to 5 failures per year. The random failure rate indicates the weakness in understanding and implementing the successful improvement plans.

The transformers Mean Time Before Failures (MTBF) during the 1999 - 2008 period is shown Figure 4.9.

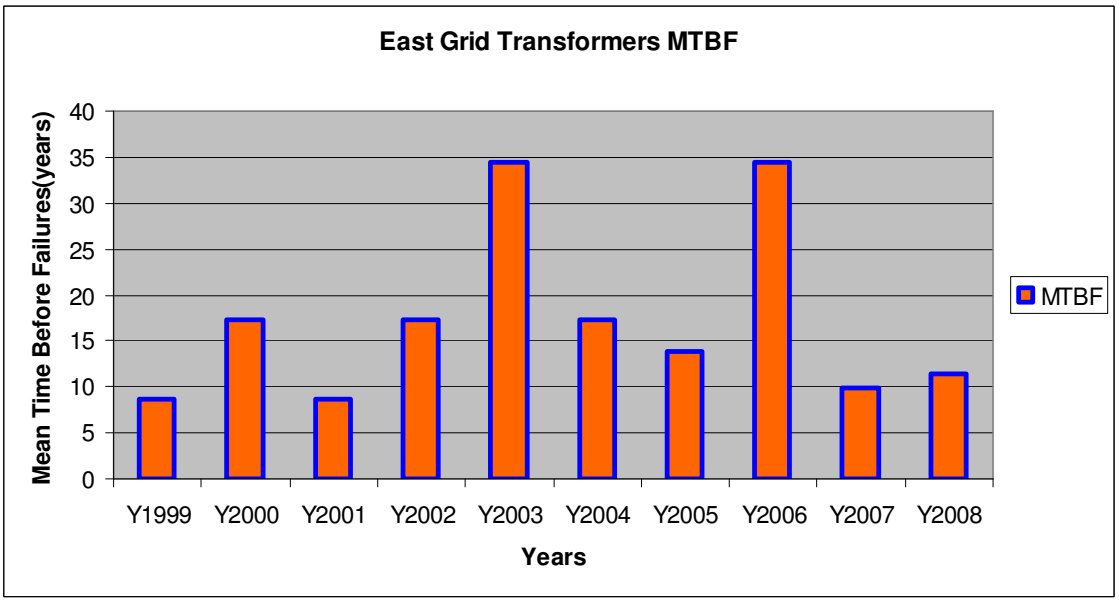

Figure 4.9 Transformer Mean Time Between Failures (TIPPS Database 1998-2008)

The aim of all the maintenance activities is to improve on Mean Time Before Failures (MTBF). The 10 year average Mean Time Betweeen Failures (MTBF) was 17 years, and highest MTBF recorded is 34.5 years in 2003 and 2006. There are no signs of improving trend of mean time before failure (MTBF) in Figure 4.9, and that means all the routine inspection and maintenance interventions are not contributing much in improving the MTBF of transformers.

4.2.2.2 Transformer Maintainability Analysis

The recovery time per incident of the transformer is shown in Figure 4.10 below.

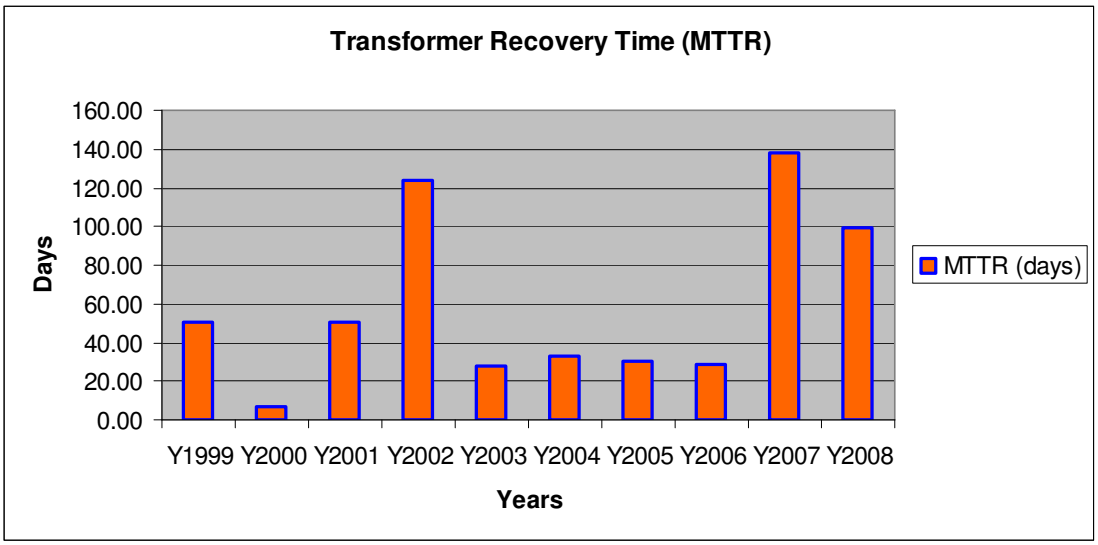

Figure 4.10 Transformer Mean Time to Repair (TIPPS Database 1998-2008)

The Mean Time To Repair of the transformer was averaged at 58.9 days, and that is very high for one failure. This major difference comes from the outage duration of the severe and non severe failures. The contribution of severe failures in 1999 (1), 2002 (2), 2004 (3), 2006 (1), 2007 (3) and 2008 (2) is reflected in high MTTR in Figure 10. The highest number of non-severe failures (8) in 2001 caused a MTTR of 50.45 days. But there are severe failures with better MTTR, the 3 severe and 1 non-severe incidents in 2004 contributed 32.92 days of MTTR. The high number of severe and non-severe failures in 2007 and 2008 caused the highest recovery time in the 10 year period.

4.2.2.3 Availability Analysis of Transformers

Transformers are one of the few equipments in the power system that require close to 100% availability. The failures on other equipments are most likely to affect the small part of the substation, while transformer failure impact the power output of the whole substation. Figure 4.11 shows the transformers availability during 1999-2008 period.

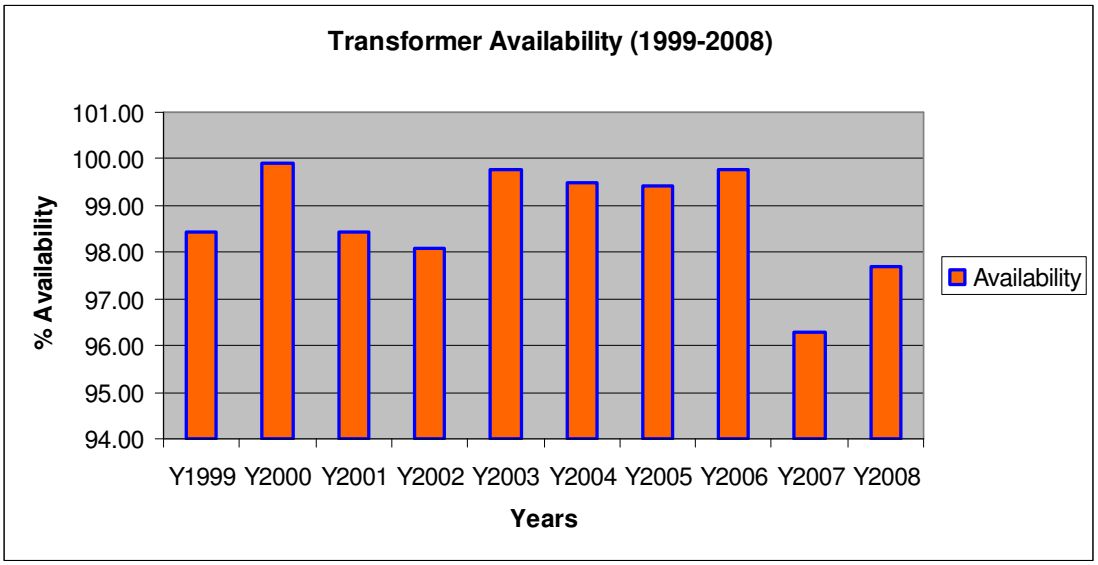

Figure 4.11 Transformers availability (TIPPS Database 1998-2008)

The transformer availability was averaged at 98.7% in the first 4 years (1999-2002). This is due to high non-severe incidents contributing to poor reliability (MTBF) and high MTTR. But it improved to an average of 99.6% availability in 2003-2006 period. After 2006 the availability started declining to the lowest of 96.29% in 2007 and 97.69% in 2008. The poor reliability in the last 2 years (2007 &2008) coupled with the longer recovery time contributed to the poor availability in 2007 and 2008.

4.2.2.4 Transformer Severe failures analysis

The analysis on the transformer severe failures between 1999 and 2008 is shown in Figure 4.12. The tapchanger is the only moving part in the transformer, and therefore it required frequent maintenance. The tapchanger failures contributed 8 out 12 severe failures between 1999 and 2008.

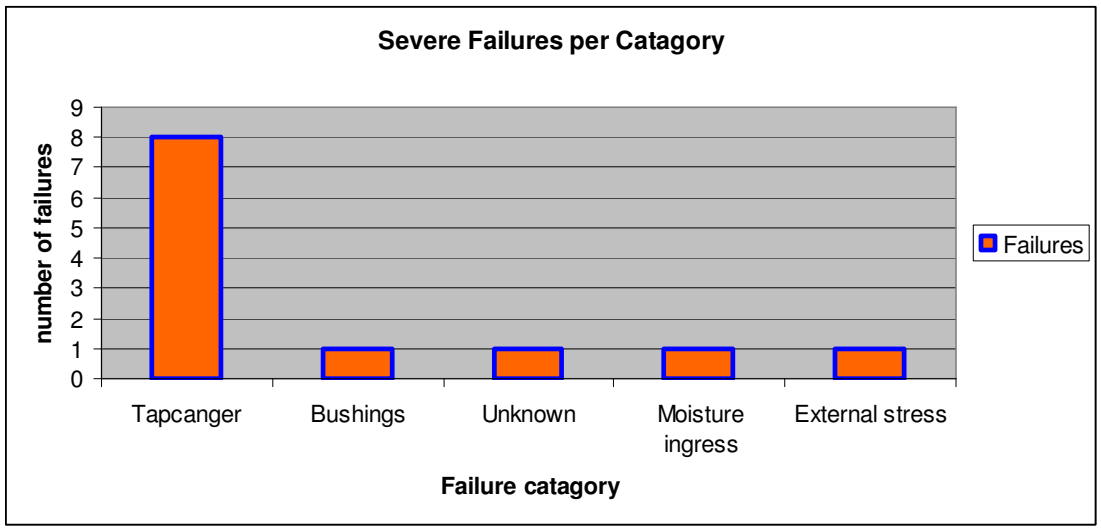

Figure 4.12 Causes of Severe Transformer failures (TIPPS Database 1998-2008)

The consequences of the severe failures highlighted in Figure 4.12 are shown in Figure 4.13 below. In the 7 of the 12 severe failures the transformers were repaired on site and returned to service. The other 5 transformer were replaced because 2 of them burnt down, and the other 3 were scrapped due to the unavailability of spares.

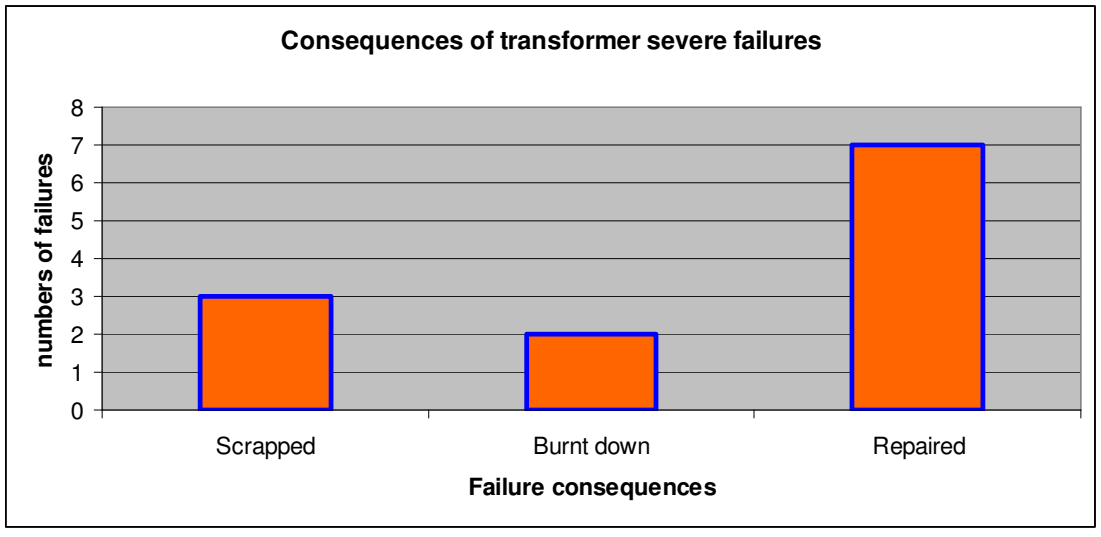

Figure 4.13 Consequences of Transformer failures (TIPPS Database 2008)

4.3 MAINTENANCE COSTS ANALYSIS

The increase in the in house capacity to do maintenance caused a sharp decrease in maintenance budget allocated to Rotek. In 2006 Rotek was only doing transformer maintenance and 10% of breaker maintenance. Figure 4.14 shows the Rotek budget for East Grid between 2000 and 2006.

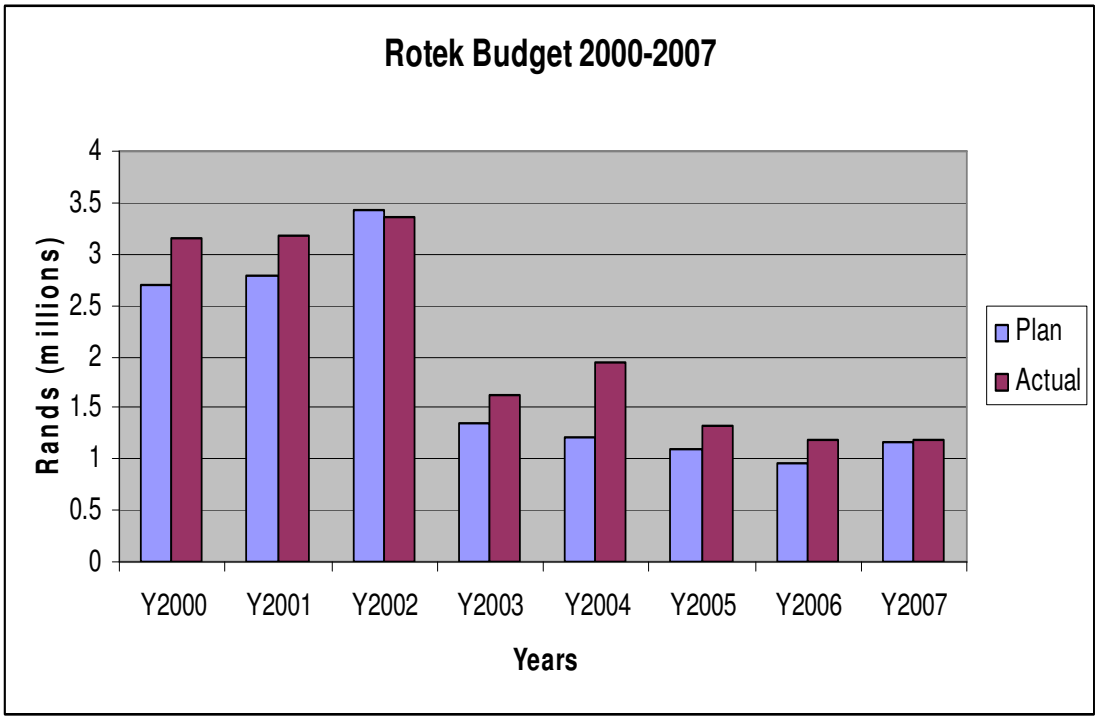

Figure 4.14 Rotek Expenditure in the East Grid (SAP Database 2008)

There was a significant drop of the Rotek maintenance budget in 2003 to 2007. The Rotek budget was above R3 million from 2000 to 2002, and it dropped below R2 million in 2003 to 2007. The Rotek budget was below R1.3million during 2005 to 2007 period.

4.4 MAINTENANCE SUSTAINABILITY SURVEY

The survey was conducted on maintenance staff to evaluate the sustainability of the in-house maintenance. The objectives of the survey were to determine the capability of maintenance staff, attitude towards maintenance and perception on insourcing or outsourcing. The survey targeted all employees who were part of the in-house maintenance establishment in 2003. Only 10

responses were received from the sample of 15 which was 66.7% of the population.

4.4.1 The capability of employees

Jackson and Schuler (2000:350) define training as improving competencies needed today or very soon. The main objective of training is to improve performance in a specific job by increasing employee's skills and knowledge. The capability of employees focused on training, level of experience and tools for the job. The objective of this measure was to assess whether the maintenance staff were given a formal and relevant training to conduct the maintenance work, and they were also afforded opportunity and support to experiment with what they learnt. Participants were asked to respond to six questions by marking whether they strongly agree, agree, undecided, disagree and strongly disagree with the statements. The employee capability results are shown in Figure 4.15

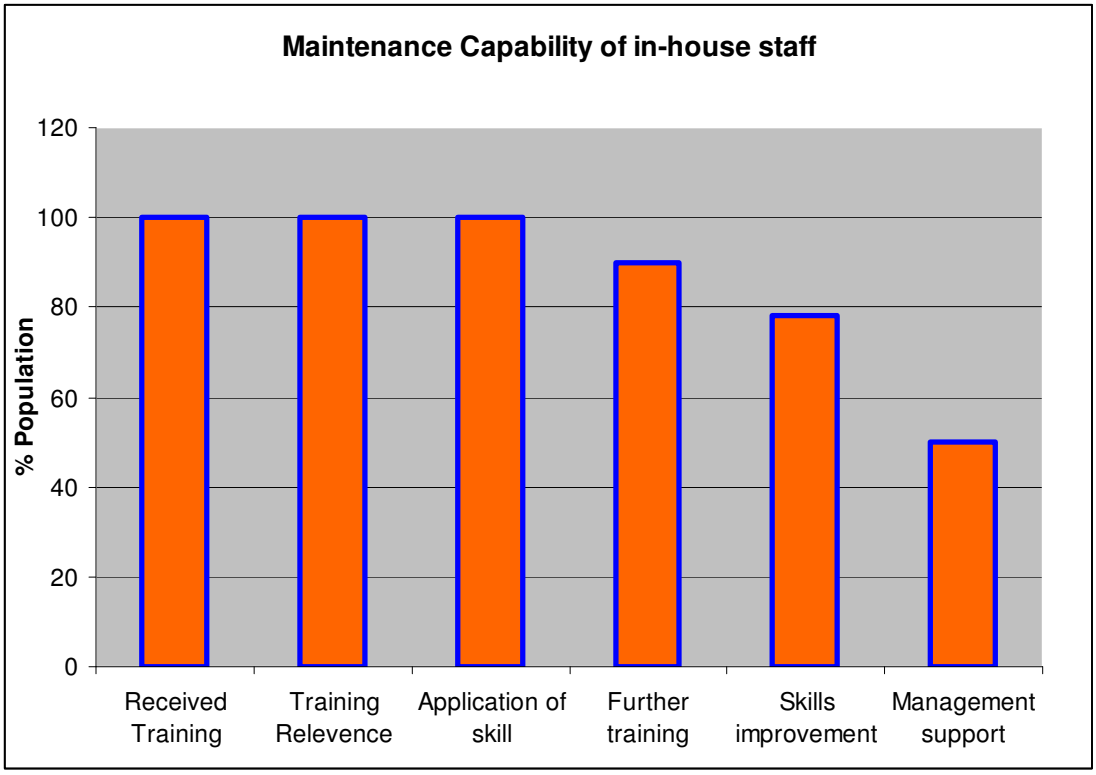

Figure 4.15 Capability of employees

The survey results indicated that 100% of the participants were formally trained in breakers and isolator maintenance. All the participants found the training relevant to their job and they were given an opportunity to apply what they have leant. The 90% of the participants encouraged more opportunity for further training and development. The 78% of participants believed their skills have improved in the last 3 years as a result of the training intervention. Only 50% of participants believed they get management support to do their jobs better.

4.4.2 Attitude of maintenance staff towards maintenance work

The participants were asked to respond to 10 questions that were designed to assess their attitude towards the maintenance work. The employees attitude results is shown in Figure 4.16

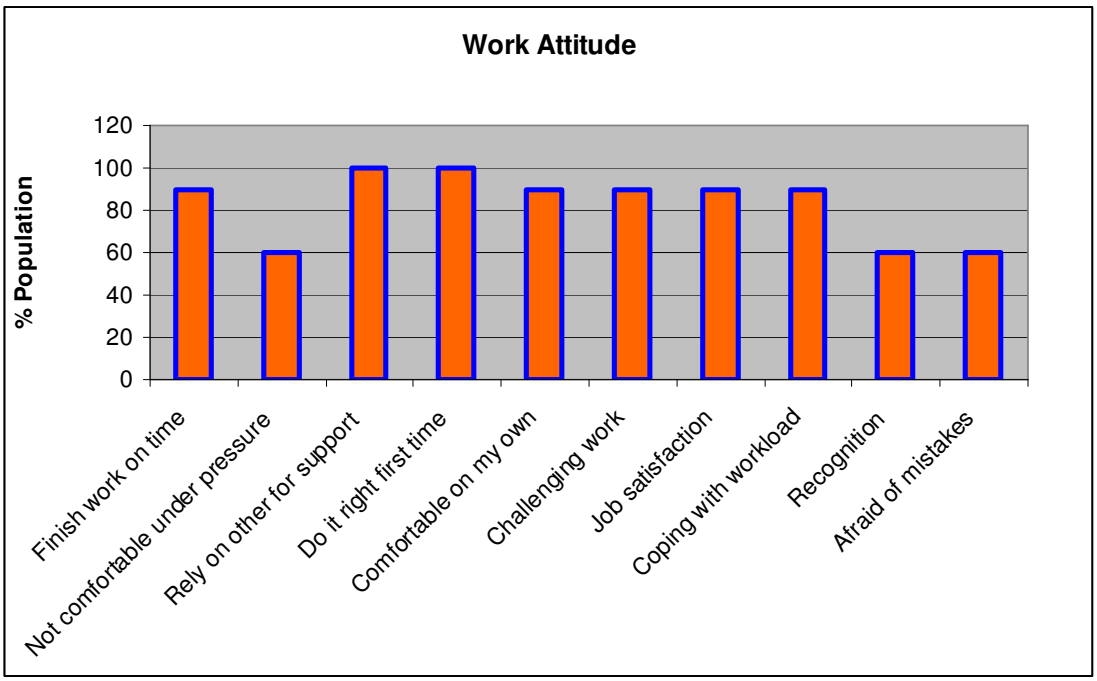

Figure 4.16 Employees attitude on maintenance

The survey results indicated that 90% of the participants felt that they were able to finish all the work on time, and they were coping with workload. The 100% of the participants indicated that they want to do their job right the first time, and they don't want to take chances. They were not afraid to seek help from technical support when they are stuck. The 90% of participants were

already very comfortable to work on their own, and they find their work very challenging. The 60% of participants are not comfortable to work under pressure and they don't want to make mistakes. The 60% of participants believed they are getting recognition for the work they do.

4.4.3 Attitude towards Outsourcing and insourcing

Employees will always have different feeling about the work being done in house, and to assess that the participant were asked to answer the six question with yes or no. The results are shown in figure 4.17

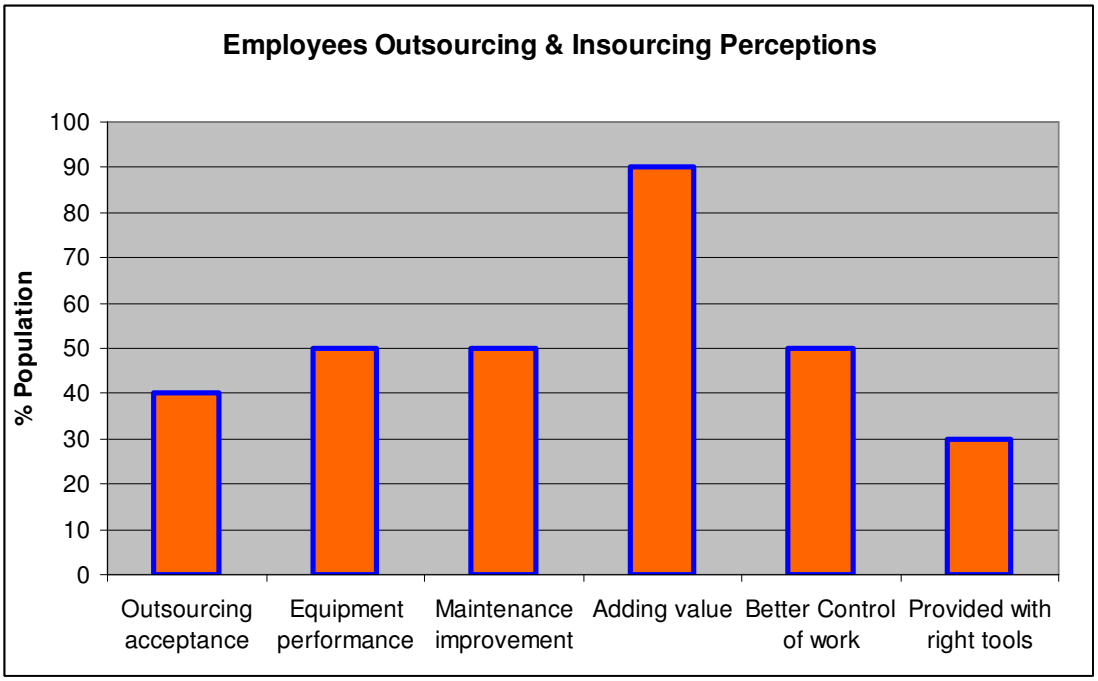

Figure 4.17: Outsourcing Perceptions

The survey results showed that 40% of participants were in favour of outsourcing. The 50% of the participants believed equipment performance have improved since the implementation of insourcing decision. Only 50% of participants believed they have better control of maintenance. The 90% of participants believed they are adding value by doing the maintenance in-house. Only 30% of participants believed they don't have the right tools for the job.

4.5 CONCLUSION

The first part of this chapter presented the quantitative research results on equipment performance analysis. The secondary data from the Eskom maintenance databases was used to analyse the equipment performance and the results were presented in a graphic format. The results revealed several interesting observations. In the survey research, the overall response received from the survey was 66.7%, and the responses were fairly distributed across the depots. The results on sustainability of maintenance insourcing were presented in a graphical format.

The discussion on the results is presented in chapter 5.

CHAPTER 5: DISCUSSIONS

5.1 INTRODUCTION

This chapter discuss the main results of the research. The primary objective of maintenance intervention (whether outsourced or not) is to reduce failures and costs. The success of any organisation depends on the health of the operations equipments that are kept in proper working order. Therefore, the key objective of maintenance activities is to maximize the availability and reliability of the operations equipment. The maintenance is said to be effective if it improves the equipment performance and reduce the overall costs. The maintenance must also be sustainable over a long period, and that required well trained, committed and dedicated staff. Training plays a big role in building the required knowledge for maintenance staff.

The goal of maximizing equipment availability and reliability and reducing costs always takes different approach from company to company. Other companies believe that the external vendor will deliver better service than the in-house staff. The literature review highlighted some of the benefits and challenges. The bottom line is that irrespective of who does the maintenance, the success of any maintenance strategy is high availability, high reliability and reduced maintenance costs.

5.2 EQUIPMENT PERFORMANCE ANALYSIS

5.2.1 Circuit Breaker Performance analysis

The circuit breaker performance analysis during 1998 -2008 period showed total number of 105 circuit breaker failures. The failure rate was constant in the first 6 years (1998-2003) with an average of 13 failures per year. Then there was a 54% failure rate improvement in the next 3 years (2004–2006) and further 50% failure rate improvement in the last 2 years (2007-2008). In total there was 77% improvement on circuit breaker failure rate from 1998 to 2008. The Mean Time Before Failure (MTBF) was almost constant in line with the failure rate in the first 6 years (1998-2003), and then grew exponential to more than 100 days in the last 2 years (2007 and 2008).

The 77% failure rate improvement in circuit breaker performance in the 11 year period showed a significant improvement in reliability of circuit breakers. The reliability of circuit breakers in the first 6 years (1998-2003) was almost constant, and that indicated the maintenance intervention that was not making any significant improvement in circuit breaker performance. The 77% reliability improvement in the last 5 years (2004-2008) can be attributed to the improvement in maintenance intervention. The improved reliability according to maintenance literature translates to less disruption to the normal operation, reduced breakdown costs and high quality of service. It can be concluded that the implementation of maintenance insourcing in 2003 had a significant improvement in the reliability of circuit breakers.

The role of maintenance intervention is to reduce failures, but in addition the successful maintenance should reduce the equipment downtime. The recovery of operation after the failures is very essential in maintenance management. The minimum Mean Time To Repair (MTTR) of circuit breakers in the first 6 years (1998-2003) was 30 hours (1.25 days), and the maximum MTTR was 260 hours (10.83 days). These figures indicate that the average circuit breaker incident was taking a minimum of 30 hours to 260 hours be repaired. The MTTR greater than 100 hours was recorded in 2000, 2001 and 2002. During these incidents the maintenance staff were taking an average of more than 4 days to repair the circuit breaker after an incident. The average MTTR during 1998-2003 period was 123.3 hours, and during 2004-2008 period the average MTTR dropped to 38.8 hours. There was an improvement of 68.5% in recovery time of the circuit breakers after the implementation of maintenance insourcing.

The recovery time or Mean Time To Repair (MTTR) has two components, namely: response time and repair time. The response time component depends on the location of the maintenance staff relative to the work site. Bragg (2006:274) noted that the response time can be a challenge when the suppliers are located away from the company's premises. The breakdown maintenance from 1992 to 2003 was done by outsourcing staff, and they resided far away from the substations. Therefore the response time for most

of the incidents was always a challenge. The repair time depends on the knowledge of the maintenance personnel, type of failure and availability of spares. The competent maintenance personnel will take shorter time to do the fault finding and conduct the repairs. There are failures that can take a very long time to be addressed, but these failures can be eliminated with equipment modification or replacement if they are critical to the operations.

The training of maintenance staff to the right competency level takes time. The Eskom staff took over the circuit breaker and isolator maintenance activities in September 2003, and it was expected that competency level will improve with more training and exposure to maintenance. Therefore the sharp increase of MTTR in 2004 (164 hours) can be attributed to incompetence of the in house staff in faultfinding and conducting the repairs. The 2004 experience helped the maintenance staff to improve the recovery time in the next 4 years (2005-2008). The decentralising of maintenance staff to all the Depots also improved the response time and flexibility especially during breakdown situation.

The availability of equipment is determined by equipment reliability (MTBF) and the recovery time after a failure (MTTR). When the Mean Time Between Failures (MTBF) goes up, availability goes up. MTTR impacts availability, the longer the MTTR, the lower systems' availability. The small fluctuations of Mean Time Between Failures (MTBF) and the escalating Mean Time To Repair (MTTR) for the circuit breakers in the first 4 years (1998-2001) caused a declining circuit breaker availability during this period. The declining Mean Time To Repair (MTTR) after 2001 coupled with the improving Mean Time Between Failure (MTBF) improved the circuit breaker availability to the highest record in 11 years in the last 4 years (2005-2008).

The availability and reliability analysis of the circuit breakers during 1998-2008 period shows that the high number of breaker incidents definitely affected the circuit breaker availability and reliability. The reliability improvement (MTBF) and the reduction of recovery time (MTTR) improved the circuit breaker availability. The reliability and availability improvement on circuit breakers

from 2004 to 2008 was the result of effective maintenance interventions and improvement in recovery time after the failure. The maintenance insourcing definitely improved the reliability and availability of circuit breakers.

There are outstanding points about the success of maintenance insourcing of circuit breakers. The reliability improvement was very quick, and that can only be achieved through adequate management of transition. The success of maintenance insourcing depended on good training and development plans. The success of the training could be attributed to the improved relationship between Eskom and the training service providers. In general the equipment suppliers understand their equipment better, therefore partnering with them in providing relevant training will normally bring better results. The opening of maintenance market in 2001 also provided an opportunity for the suppliers to explore the training opportunities.

The effectiveness of the training intervention also came as a result of good analysis of the company resources. The Eskom field staff are normally trained to the artisan level, but they were only utilized for switching and inspections only (underutilized). The interest of equipment suppliers in providing training provided an opportunity to train the in-house staff to do maintenance that was previously outsourced. Obviously when embarking on big initiative like maintenance insourcing, there is a need to motivate the employees to participate in training by offering incentives, employees were encouraged to practice newly learned skills. The employees who successfully use the new competencies were recognized.

The absence of performance improvement during outsourcing period of cannot be understood. But it is generally known that when outsourcing is driven by skills requirements, the reality is that the suppliers also do loose capabilities which can lead to the failure to maintain or improve the service. While the organization may turn to outsourcers to fill gaps in its own staff, they may discover that the outsourcer suffer the same quality and retention problems. In most cases the outsourcing company have a tendency of playing down the skills challenges to their client in the interest of keeping the

business. Instead they will opt to provide the inferior service which will lead to poor equipment performance.

According to Insinga and Werle (2000:1), one of the outsourcing risks is that outsourcing can lead to the dependency on outsourcing company and that can create unforeseen strategic vulnerabilities. When maintenance activity is outsourced to the external supplier, it is a fact that the supplier becomes more knowledgeable about the plant than the internal staff. When the maintenance was brought in-house the improved competency level of internal staff started showing up in circuit breaker performance. The reliability improvement was sustained over a period of 5 years.

The improved competency level influenced how maintenance is done. One of the benefits of the improved competency level is that the plant failures is properly investigated and thoroughly discussed amongst the maintenance teams. When maintenance is done in-house, the internal staff starts to understand the failure patterns and respond by implement appropriate maintenance strategy. The adjustments are made to some of the preventative maintenance strategy to improve the performance. The maintenance insourcing also provides an opportunity to explore the new maintenance technologies, and hence the introduction of condition based maintenance technique on circuit breakers has reduced the breaker incidents next to zero.

The circuit breaker performance clearly shows that the maintenance insourcing did improve the maintenance performance. The improved circuit breaker maintenance have reduced the disruption of electricity supply, and hence improved the quality of supply to the customers. The response time improved because the skills are closer to the plant. More than anything, the in-house staff were also flexible to adjust with the outages availability.

5.2.2 Transformer performance analysis

The total number of transformer failures in the East Grid during 1999-2008 period was 50. The non-severe failures contributed 76% (38) while the severe failures were 24% (12). There are 69 power transformers in the East Grid, and

therefore this means over a period of 10 years the transformer failures averaged at 5 incidents per year. The one transformer failure has a potential to cause a major disruption to the electricity supply and serious costs implication. The year to year failure rate was very much random, when one year is better and the following year is worse and that makes it difficult to understand the effectiveness of maintenance.

The non-severe failures have a potential of causing severe failures, therefore the 76% contribution of non-severe was very alarming. Most of these non-severe failures can be eliminated by condition monitoring and through regular inspection. However, the adequate the transformer inspection can only be achieved when the transformer is out of service and that only happens during the preventative maintenance which is done once every 3 years. When preventative maintenance is outsourced, one can only rely on the outsourcing contractor to do the inspections. As long as the transformer maintenance is still outsourced, it cannot be ruled out that these inspections are not done properly by the contractor.

Severe transformer failure means that the transformer should be replaced or major repairs are required on site or at Rotek Workshop. The transformer replacement or repair can take more than 3 months and that can constrain the electricity supply. The 12 severe incidents in 10 years equate to more than one severe transformer failure per year. The 5 of the 12 severe transformer incidents resulted in transformer replacement and severe oil spillage. The tapchanger failures contributed to 66% (8/12 failures) of the transformer severe failures, and this is the only moving part in the transformer that need regular maintenance.

The transformer reliability analysis that covers both severe and non severe failures indicated a random failure rate with no specific trends. The 10-year average failure rate was 0.072, and that equate to an average failures of 5 incidents per year and the average Mean Time Betweeen Failures (MTBF) of 17 years. The random failures can be an indication that the maintenance interventions are not adequate enough reduce the failures. The reliability of

transformers can only show positive improvement with the reduction of both severe and non-severe failures.

The recovery time (MTTR) of transformers was very high compare to circuit breakers. The faultfinding on the transformer takes longer than any other substation equipment because of the complexity of the design. The severe failures contributed the most in the recovery time. The periods with high severe failures had recovery time of more than 50 days, with the highest recovery time of 140 days in 2007 (3 severe failures). However there are exception like the 3 severe failures and 1 non-severe failure in 2004 which led to the recovery time of 32.7 days. In 2001 the 8 non-severe failures contributed 50.4 days of recovery time. The improvement on transformer recovery time also depends on the extent of damage and the availability of spares. The scrapping and replacement of the burnt transformer normally takes longer compare to the other failure mode. The quicker the spare unit is made available the shorter the recovery time.

The transformer recovery time (MTTR) depends on response time, type of failure and repair or replacement time. The response time is largely affected by the proximity of maintenance staff from the substation. The outsourced transformer maintenance is always a challenge when the contractor is responding far from the work site. In this case Rotek Engineering normally responds from Johannesburg workshop, which is over 400km away from KwaZulu Natal substation. There response time also depends on skills and equipment availability. The response time had a major contribution to the recovery time of transformers.

The procedure of returning the transformer back to service after the trip is a long process. Unlike the circuit breakers where most of the active part are exposed, the transformer active part are concealed inside the transformer main tank and it requires some diagnostic tests to prove if all the active parts are still in order. Therefore irrespective of whether the failure is severe or not, the diagnostic tests will always increase the recovery time. Obviously the severe transformer failure is associated with long outages while carrying out

repairs or replacement. It must be noted however that the reduction in transformer incident will reduce the downtime and improve the availability of the transformers.

Availability is a function of reliability (MTBF) and recovery time (MTTR). The reduction of transformer incidents will improve the transformer reliability and availability. The reduction of recovery time through quick response time and shorter repair time will improve the outage time and improve availability. Inversely the poor reliability due to high failure rate and longer recovery time will reduce the availability of transformers. The high number of transformer severe and non-severe failures from 1999 to 2002 coupled with long recovery time (MTTR) caused the poor transformer availability. The same scenario was experienced in 2007 and 2008.

There was no evidence of improvement in the transformer performance during the 10 year period. The reliability was very much random, and the recovery time was very long especially for severe failures. The alarming trend was the severe failures in the last 3 years (2006-2008). This might raise a question whether it is still a good decision for Eskom to keep transformer maintenance outsourced to Rotek.

5.3 MAINTENANCE OPERATING COSTS

The maintenance budget started shrinking immediately after implementation of the in-house circuit breaker maintenance in 2003. In 2005 100% of the circuit breakers and isolators maintenance was done in-house. The transformer tapchanger maintenance was the only maintenance activity outsourced to Rotek. The maintenance expenditure on Rotek dropped by more than 50% from 2005 to 2007 period.

There was a slight increase in Eskom manpower costs due to the improved compensation of maintenance staff, and later with an additional two specialists to assist the existing staff. The benefit of additional manpower was to increase the capacity to do other maintenance in house. The Grid was able to perform the major overhaul on any type of circuit breaker without any

supervision from manufacturers. This also enabled them to do all the modifications and defects are done in-house and on time.

The new circuit breaker specialist was also trained and authorised to conduct training on most of the circuit breakers, and that also reduce the training costs. Some of the training revenue came from other divisions who use the East Grid specialist for training requirements. In 2006 the Grid business (which covers 7 Grids) started virtual team which work across the Grids to expand the knowledge to the large number of employees. All these initiatives improved the circuit breaker performance and in-house maintenance capacity, and reduce the training costs.

5.4 SUSTAINABILITY OF IN-HOUSE MAINTENANCE

The survey was conducted on maintenance staff to assess the sustainability of the maintenance insourcing. The maintenance efforts are sustainable if the company is able to build maintenance capabilities and the maintenance staff also have a positive attitude about their maintenance work. According to the survey results, the maintenance staff were given formal training, and the training was relevant to their jobs. The employees also appreciated the opportunities given to them to apply their new skills. There was a generally view that their skills level had improved over the last 3 years, and this was reflected in the improved breaker performance. Because of the continuous challenges associated with doing maintenance, the employees are open for further training to sharpen their skills. There was also a feeling that management support was not adequate, and therefore management visibility and communication could improve this area.

In general training and development are intentional efforts to improve current and future performance by helping employees acquire the skills, knowledge and attitudes required of a competitive work-force. The improved circuit breakers performance was the results of improved competencies of Eskom staff through training. The gaps between the employees' current capabilities and those identified as desirable were properly identified, and the training programs were developed to address that. The training was effective in

addressing the immediate challenges of improving the equipment performance. Management support was always going to be a challenge because the training programmes must be supported by other formal and informal programs like supervisory assistance or mentoring. These programs are design to provide opportunity for growth, create a feeling of mutual confidence and guide development of less experienced workers. The low management support shown by the survey indicates how bad this part was managed during the process.

Organizational behaviour is only concerned about three attitudes at work, and these are organizational commitment, job involvement and job satisfaction. The majority of the participants in the survey demonstrated their commitment and willingness to work harder to achieve the organizational goals. The 90% of the participants indicated that their work was very challenging, but they were able to finish the work on time and they were coping with the workload. The 60% of the participants were very carefully about causing mistakes.

The majority of the participants believed that they are adding value to the company, and they hold positive feelings about their work. All the participants indicated that whenever the do the work it must be right the first time. The 60% of the participants were very careful about causing mistakes and the same percentage was not comfortable to work under pressure. The participants demonstrated high level of job involvement.

The 90% of the participants were satisfied with their job, they were comfortable working on their own. They relied on other supporting systems to do their work properly. The improved equipment performance was a good indication of high level of commitment, job satisfaction and job involvement in their jobs. These are all the conditions that allow the quick transfer of knowledge base that is required in the maintenance environment. The team working under these conditions is likely to deliver at high and consistent productive level.

The survey showed a low satisfaction when it comes to recognition and rewards. This was going to be a big challenge if one look at that these employees were seriously underutilised and now they find themselves doing more work. As much as incentives were given to the employees to compensate them for doing extra maintenance, there will a feeling that they deserve more. One may argue that there will never be satisfaction when it comes to compensation, however it is very important that we understand what cause these feelings.

The 40% of the participants supported maintenance outsourcing, which implied that 60% of the employees are in favour of maintenance insourcing. Most of the employees paid less attention on the improvement in maintenance and equipment performance. As much as employees enjoyed the opportunity, but they were not sure whether they are doing things better. The reason for this might be that employees are very much involves in maintenance and they don't pay attention on performance data. Only 30% of the participants felt that they are provided with enough tools to do their job effectively.

The miscommunication on the effectiveness of the maintenance can be very dangerous. If the employees are not getting the continuous feedback on how their maintenance contributes to the stability of the company, this might contribute negatively on motivation, job involvement, job performance and staff turnover. Employees might end up feeling like they are not adding value by doing the maintenance and start neglecting things.

5.5 CONCLUSION

The primary objective of maintenance intervention (whether outsourced or not) is to reduce failures and costs. The drive to improve to reduce failures and maintenance costs takes different approach from company to company. Other companies believe that the external vendor will deliver better service than the in-house staff. The analysis of maintenance performance in Transmission East Grid revealed that the maintenance activities can be done better in-house. The assumption that the external service providers would surely have developed expertise in your maintenance issues from having

handled exactly the same services and situations in other companies can be misleading.

The circuit breaker performance improved drastically after Eskom internal staff started doing maintenance. The outsourced transformer maintenance activity showed no improvement in transformer performance. The alarming factor was the high failures caused by tapchangers, it raise a question on the quality of maintenance. The insourcing of circuit breaker and isolators maintenance did reduce the maintenance costs.

The survey results on the sustainability of maintenance insourcing indicated that internal staff supported the insourcing decision. They were very committed to make the maintenance insourcing a success.

The conclusion and recommendations are presented in the next chapter (chapter six).

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

As organisations today strive to achieve minimum operating costs and lean operations in terms of manpower, the maintenance activity has become a target for outsourcing. With a growing shortage of skilled and experienced maintenance engineers, facility management companies provide an attractive alternative to the traditional approach to maintaining assets. However, for many organisations, maintenance is close to the core of their operations and the decision to outsource is a difficult one. In theory, handing responsibility to someone else allows additional time and attention to be diverted to more core or critical processes/sections of the business. After all, the external service providers would surely have developed expertise in your maintenance issues from having handled exactly the same services and situations in other companies.

The organisations choose outsourcing for different reasons such as improved flexibility, acquire new skills, enhanced controls, focus on core functions, avoid investments and reduced operating costs. While there can be many good reasons to outsource a function, there are number of risks associated with outsourcing. Some examples include loss of flexibility, increased costs and dependency on outsourcers. The primary objective of an organisation to outsource maintenance function is to reduce operating costs and improve on plant performance. The organizations are in business to make profit out of their resources. Therefore, good health of any company depends on operations equipments that are kept in proper working order. The desired outcome of maintenance intervention is to improve reliability and availability of equipment. Obviously, this objective must be attained in a cost-effective way and in accordance with environmental and safety regulations.

6.2 RESEARCH CONCLUSION

The objective of this study was to identify the maintenance key performance indicators (KPI's) and use these KPI's to evaluate the challenges and success of maintenance outsourcing and insourcing in Transmission East Grid

between 1998 and 2008. The aim of the research was first, to gain an understanding of maintenance outsourcing and insourcing, including the identification of the drivers, the critical success factors and the benefits. This information was used to identify the critical performance measures that could be used to analyze the effectiveness of maintenance activities in Eskom Transmission. The key performance measures that were identified to evaluate and compare the effectiveness of maintenance outsourcing and insourcing were the maintenance costs, reliability and availability. In addition the research also attempted to answer the question whether the insourcing of circuit breakers and isolators was sustainable.

The effective maintenance (whether outsourced or insourced) should improved the reliability and availability equipments. The performance of circuit breakers and transformers were chosen for this study, and the reasons were that they are most critical equipments in the supply of electricity and they individually contribute the highest to maintenance costs. In addition the circuit breaker and isolator maintenance were brought in-house in September 2003 and the transformer maintenance was still outsourced. This part of the research adopted the quantitative research approach by using the internal secondary data to analyse the reliability, availability and maintenance costs,. The secondary data was acquired from the Eskom maintenance databases.

The results from the research revealed that the circuit breaker performance in the East Grid circuit breakers during the outsourcing period (1998-2003) was almost constant, and averaging at 13 failures per year. The failures dropped to an average of 6 failures per year during the insourcing period (2003-2008). The failure rate improved by 77% during the 11 year period (1998-2008), and the 75% improvement happened during insourcing period (2004-2008). The circuit breaker Mean Time To Repair (MTTR) or recovery time also improved by 68% during insourcing period (2004-2008), and that means the restoration time improved drastically during insourcing period. The improvement in reliability (failure rate or MTBF) and recovery time (MTTR) improved the circuit breaker availability.

The 77% failure rate improvement, the 68% improvement in recovery time and improved circuit breaker availability matches the maintenance insourcing period. Immediately after the implementation of the insourcing decision in September 2003, the circuit breakers performance trends showed a positive improvement. The only explanation to this improvement is good quality of maintenance done by in-house staff and flexibility brought by insourcing. The insourcing decision came with a number of benefits which improve the overall performance of circuit breakers. The in-house staff developed a good knowledge of circuit breakers, and as a result they were able to conduct proper inspections and attend minor defects before they become major. The response to faults was also reduced because of the proximity of staff to the substation.

The findings on the transformer performance were that the transformer failure rate during the 10 year (1999-2008) period was very much random, and that becomes a challenge to understand the effectiveness of maintenance. The 10-year average failure rate was 0.072, and equate to 5 failures per year. The failure rate was not showing any signs of reliability improvement, therefore it could not be concluded that the maintenance activities was effective. The restoration of transformers was normally longer than the circuit breakers and that impact its recovery time (MTTR). The poor reliability of transformers and longer recovery time affected the transformer availability negatively.

The tapchanger contributed 67% to the severe transformer failures, and it raised serious questions which amongst others is the quality of tapchanger maintenance. Unfortunately the root cause of the tapchanger failure was not cover by the research scope, but it was noted that as the only moving part in the transformer and it subjected to regular maintenance, good maintenance should reduce the risk of failure. The transformer severe failures had increase in the last 3 years, and that was worrying when one considering the serious consequences of this type of failure.

The conclusion on transformer performance was that there was no evidence of improvement in the last 10 years. Therefore there was no evidence to

suggest that transformer maintenance was effective. The transformer maintenance at the time of this research was still outsourced to Rotek.

There has been a significant reduction in maintenance costs since the insourcing decision was implemented. This was an evidence of the contribution of circuit breakers in the maintenance costs. The key was for East Grid to optimise the existing resources to bring efficiency. There was only a small increase in manpower costs due to additional breaker and transformer specialists, but the savings on maintenance outweighed the additional costs. Obviously there was a good benefit of reduced breakdown costs due to low failures and failures being attended in-house.

The survey research was used to study the sustainability of maintenance insourcing. The survey was conducted on maintenance staff to establish the capabilities of doing maintenance in-house, the attitude of the maintenance staff towards maintenance insourcing. The finding was that maintenance insourcing decision did improved staff competency and motivation. The employees' attitude was positive about their involvement in maintenance. The maintenance staff felt they were adding value by doing maintenance in-house. It has also created a career growth for some of the employees who wanted to develop further. They were coping with workload and the challenges that come with the work. The staff would like to see more management support when it comes to mentoring and coaching.

The research managed to achieve its original intent, and it has demonstrated that the benefit of outsourcing might not be real in the long term. The outsourcing firm are also experiencing the same challenges of skills, demotivated employees and others. Therefore, it is a duty of the client to includes and monitor performance measures in the maintenance contract. This will be ideal in identification the problem while the damage is manageable.

In conclusion, the maintenance insourcing decision managed to improve the circuit breaker performance. The maintenance costs have come down

drastically, and the Grid has a better control on maintenance costs (including breakdown costs). The insourcing decision was effective in improving technical and financial performance of the Grid.

6.3 RECOMMENDATIONS

The success of outsourcing is embedded on the details of the outsourcing contract agreement. The contract agreement which does not spell out the expected performance level and the key performance indicators is bound for failure. The outsourcing success also requires a continuous assessment of the key performance indicators to identify and correct the shortcomings during the contract period. The absence of performance management in outsourcing can be interpreted as dumping the function to the outsourcers and accept any outcome.

Insourcing the maintenance function can have its own multiple challenges. The long term success of the insourcing can be achieved by looking at the following recommendations.

- **Continuous investment on training and development**: The employees will always require training intervention to improve the skills on the existing plant and to meet the demands of the new technology. The highest performing company embark on programs that enhance employee's ability to perform at highest peak. This requires resources like money and time.
- **Internal measures for maintenance improvement**: According to the maintenance experts what is not measure it cannot be improved. The maintenance is done to improve reliability and availability of plant, this must be cost-effective as well. This expected level of performance must be discussed with the maintenance teams upfront and be used as the maintenance measure. The continuous communication on maintenance performance with maintenance teams should promote good behaviour.
- **Maintenance audits**: The continuous audits on maintenance always identify any shortcomings and correct those before it become a serious problem.

- **Mentoring and Coaching**: The employees believe in career progression, and this requires guidance from the senior management about how the company assist in that regard. This requires formalised programs that can improve growth opportunities for maintenance staff.
- Management must attend to the short term staffing problems.
- Promote teamwork, eliminate fear, individualism.
- Communicate reward system constantly and discuss expectations.
- Communicate equipment failures (improvements) to the maintenance teams.
- Consider taking over the maintenance of transformers.

6.4 FUTURE WORK

The results of the study were influenced by the secondary data used, the survey conducted and the literature review. The research only focused on one of the eight businesses of Eskom Transmission Grids. Due to time constrains of this study, further work may be conducted on the following:

- Effectiveness maintenance insourcing in Eskom Transmission Grids: The study only focussed on equipment performance in East Grid, and this cannot be generalized for the rest of the Grids business.
- Further investigation on other business sectors: The study was conducted on electricity utility and it will be interesting what is happening in other industries.

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APPENDICES

Appendix C: Calculations Examples

Reliability Calculations

1. Failure rate = $\left(\frac{number\ of\ \ failures}{units\ installed}\right)\left(\frac{1}{number\ \ years}\right)$

   Using 1998 Breaker information

   - Number of circuit breaker failures = 12
   - Number of circuit breakers installed = 429

   Failure rate = $\left(\frac{12}{429}\right)\left(\frac{1}{1}\right)$ = 0.0279 per year

2. Mean Time Between Failures (**MTBF**) = $\left(\frac{1}{Failure\ rate}\right)$ = 35.75 years

Maintainability Calculations

1. Mean time to repair (**MTTR**) = $\left(\frac{Total\ \ Downtime\ \ from\ \ failures}{Number\ of\ \ failures}\right)$

   Using 1998 circuit breaker information

   - The total downtime from circuit breaker failures = 1082.27 hours
   - Number of circuit breaker failures = 12

   Mean time to repair (**MTTR**) = $\left(\frac{1082.27\ hours}{12\ failures}\right)$ = **90.19 hours / failure**

Availability Calculations

1. Availability = $\left(\frac{MTBF}{MTBF + MTTR} \right)$

   Using 1998 circuit breaker information

   - MTBF = 35.75 years = 313170 hours
   - MTTR = 90.19 hours

   Availability = $\left(\frac{313170}{313170 + 90.19} \right)$ = **99.97%**

Appendix D: Reaserch Questions

QUESTIONNAIRE

This questionnaire is being administered to engineering assistants and maintenance specialists to assess the staff morale and attitude which might have been caused by maintenance insourcing decision. The questionnaire should take only 15 – 20 minutes to complete. There is no right or wrong answers. Rather these are your personal opinions and perception that count. If you would like to develop any answers you give or make any other comment please put these at the end of the questionnaire. The questionnaire should be completed anonymously. Thank you for your cooperation.

How to complete the questionnaire

1. please answer as truthful as you can
2. You can mark each response by making a tick or a cross.

Part 1: Training

1. I was given a formal training in my field of work.

   _____ Strongly agree _____ Strongly disagree

   _____ Agree _____ Disagree

   _____ Undecided

2. The training was relevant to my job

   _____ Strongly agree _____ Strongly disagree

   _____ Agree _____ Disagree

   _____ Undecided

3. I get a chance to apply what I learnt.

   _____ Strongly agree _____ Strongly disagree

   _____ Agree _____ Disagree

   _____ Undecided

4. I get support from management to do my work better.

_____ Strongly agree ____ Strongly disagree

____ Agree ____ Disagree

____ Undecided

5. My technical skill has improved in the last 3 years.

_____ Strongly agree ____ Strongly disagree

____ Agree ____ Disagree

____ Undecided

6. I am open for further training.

_____ Strongly agree ____ Strongly disagree

____ Agree ____ Disagree

____ Undecided

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Part 2: Attitude at work

1. I take my time to finish the work

_____ Strongly agree ____ Strongly disagree

____ Agree ____ Disagree

____ Undecided

2. I don't like to work under pressure.

____ Strongly agree ____ Strongly disagree

____ Agree ____ Disagree

_____ Undecided

3. I ask if I don't know.

_____ Strongly agree _____ Strongly disagree

_____ Agree _____ Disagree

_____ Undecided

4. I don't take chances, I want to do it right.

_____ Strongly agree _____ Strongly disagree

_____ Agree _____ Disagree

_____ Undecided

5. I am comfortable to work on my own.

_____ Strongly agree _____ Strongly disagree

_____ Agree _____ Disagree

_____ Undecided

6. I find the work very challenging.

_____ Strongly agree _____ Strongly disagree

_____ Agree _____ Disagree

_____ Undecided

7. I get job satisfaction in my job.

_____ Strongly agree _____ Strongly disagree

_____ Agree _____ Disagree

_____ Undecided

8. I can cope with the workload.

   _____ Strongly agree _____ Strongly disagree

   _____ Agree _____ Disagree

   _____ Undecided

9. I get good recognition for the work I do.

   _____ Strongly agree _____ Strongly disagree

   _____ Agree _____ Disagree

   _____ Undecided

10. I am afraid that I will make mistakes in my wok.

    _____ Strongly agree _____ Strongly disagree

    _____ Agree _____ Disagree

    _____ Undecided

Part 3: Outsourcing

Answer these questions with **yes** or **no**

1. Would you accept if you work is outsourced?
2. Do you think equipment performance has improved?
3. Do you think we are doing things better than before?
4. Do you think you are adding value to the company?
5. Do you have a better control on your work?
6. Do you have right tools for your job?