Maintenance management for effective operations management at Matimba Power Station

by

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Mini-dissertation submitted in partial fulfilment of the requirements for the degree of Master in Business Administration at the Potchefstroom Campus of the North-West University

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November 2009

ABSTRACT

Effective and efficient operations management is the cornerstone of any company's success. Presently, because of cost-cutting pressures, all investors look out for companies' operations before making any investment commitment. The South African Government (through the Department of Public Enterprises), as an owner and investor in Eskom, is looking at optimising operational excellence within state-owned enterprises like Eskom.

Eskom is presently experiencing problems with increased electricity consumption which it cannot meet due to the limited plant capacity it presently has. These challenges are forcing Eskom to be more efficient and effective in management of the present plant assets (like Matimba Power Station) it presently operates.

Matimba Power Station has consistently shown improvement in the areas of plant, financial and operations performance over the last three years. It is presently the standard bearer for the whole Eskom in terms of plant and operational performance. Asset management (through maintenance and management thereof), especially preventative management within a power utility like Eskom, is a critical factor because supply (generation of electricity) has to meet demand (consumption of electricity) instantaneously as electricity cannot be saved. The planning, scheduling and execution of maintenance (through a work management process) to ensure success of business operations are very critical. An Eskom document titled *Routine Work Management Manual* emphasised the criticality of preventative management and included a six-step process of work management within the power generation business.

The Japanese success in ensuring that operations costs are limited by implementing total productive maintenance (which includes work management) is suggested in the study as a way to go for operational success at Matimba Power Station. Many of the research studies done at Eskom in regard to maintenance were based on and confined to a sampling population of senior staff members like managers, engineers and supervisors. Experience has shown that progress of implementing change (whether in systems or structures) is slow if there was no proactive involvement of all participants and stakeholders, especially employees at lower levels involved in operations. A work management process, which is one of the pillars of total productive maintenance, was recently implemented at Matimba and is currently experiencing teething problems which are being attended to. Employee involvement in making sure of the success of work management is critical. The study investigates the implementation of work management from the employees' perspective in order to address problems for possible full implementation of total productive maintenance.

Key words: Operations management; maintenance management; power station; work management; total productive maintenance; preventative maintenance

ACKNOWLEDGEMENTS

I would like to acknowledge the following persons for making this study a reality:

- My deepest gratitude is to my Heavenly Father, who took me from nothing to great heights.
- I would like to thank my supervisor, Mr Henry Lotz, for his guidance throughout the research.
- I am grateful to the staff at Potchefstroom especially Wilma Pretorius for the passion for her work and assistance to all MBA students throughout the years of our studies. She is a real example to us.
- My deep appreciation is to my children, Mpho, Katlego and Tshiu, for their support through the most stressful period.
- My wife, Pinky, who has been a rock for the foundation we are laying.
- To my mother, who fought for 42 years of being a widow to make sure that her children go through life's challenges.
- Mrs Antoinette Bisschoff, for editing the text.

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LIST OF ABBREVIATIONS

BTL	Boiler Tube Leaks
BU	Business Unit
CBM	Conditioned Based Maintenance
CM	Corrective Maintenance
CMMS	Computerised Maintenance Management System
ERA	Electricity Regulation Act
ERP	Enterprise Resource Planning (system like SAP)
ERP	Enterprise Resource Program
EPRI	Electricity Power Research Institute
GO	General Overhaul
HMI	Human Machine Interface
JIPM	Japanese Institute of Plant Management
JIT	Just in Time
KPA	Key Performance Area
KPI	Key Performance Indicator
LOPP	Life of Plant Plan
MW	Megawatt
MTBF	Mean Time between Failures
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety Act
OMS	Occurrence Management System
OPSLOG	System used by Operating Department to log in daily Plant incidents
OTS	Operating Technical Specification
PCLF	Planned Capability Loss Factor
PM	Preventative Maintenance
PQP	Process Quality Plan
QCP	Quality Control Procedure
RCM	Reliability Centred Maintenance
RFID	Radio Frequency Identification
RPL	Recognition of Prior Learning

SAP PM Module	ERP sub-module used in Eskom generation for maintenance management
SAP	System Application ERP System used by most companies in South Africa
TPM	Total Productive Maintenance
TPS	Toyota Production System
TPS	Toyota Production System
UCF	Unit Capability Factor
UCLF	Unplanned Capability Loss Factor
WM	Work Management

CHAPTER 1

NATURE AND SCOPE OF THE STUDY

1.1 INTRODUCTION

It is the first time in Eskom's 80 years' history as a public services utility to attain such media scrutiny regarding operational performance of its power stations. The January 2008 country-wide load shedding was unprecedented in its scale and impact and has caught the attention of all in the country. This is, to some extent, good that customers and the public at large, understand the operational difficulties Eskom Generation Division face.

The load growth (demand in Megawatt hours) is exceeding the total generation capacity additions (supply growth), thus forcing Eskom National Control to shed load to balance the demand and supply. This is also forcing Eskom power stations to be highly effective in ensuring electricity supply availability. This means that Power Plant needs to be available for electricity most of the time.

Eskom is presently sweating its plants (power stations) due to shortage and non-availability of supply capacity (for electricity generation). All Eskom plants are presently operating 90% of the time whereas the international norm is 75%. This leaves little time to do effective maintenance on the plant, because maintenance will force equipment to be taken out of operations thus limiting available electricity for consumption.

The current worldwide economic crisis has added to the challenges Eskom are facing and this makes Eskom's situation more critical, because many of its large customers or wholesale users (for example, high power users like industries and mines), have scaled down operations thus limiting Eskom's revenue. The only customer base increasing is small power users (for example, domestic users) who are expensive to service unlike wholesale users. The small power users are also troublesome for Eskom to service due to continued theft, limited revenue received and injuries sustained due to theft. The electricity consumption among this user group is also increasing due to the large-scale electrification project the Government has undertaken.

Maintenance and the effective management thereof within the power stations play a pivotal role in ensuring availability of plants for generating electricity. Half, or more, of the resources (such as finance or manpower) used in production, operations and management in power plants (including Matimba) are maintenance related. Another factor is that power stations are a capital-intensive (that is, high capital value equipment) sector that needs maintenance activity to prolong the lifespan of the plant. The lifespan of a power station like Matimba is more than fifty years, and a maintenance effort is made to prolong its life in order to get maximum value and repay the initial capital outlay.

Preventative management (PM) as a stand-alone initiative is also proving to be problematic, especially in the area of cost saving. The present popular initiative is total productive management (TPM) which is popular within Japanese companies because of its cost advantages. Companies like Toyota has used this principle successfully to enable it to capture the number one spot as the most profitable motor company in the world.

Addressing maintenance as a stand-alone entity, will not address some of the operations problems, so a systems approach is looked at to address some of the integration issues within, involving technical departments at Matimba, but maintenance remains at a core as the biggest cost contributor at Matimba.

The TPM which includes the Maintenance Work Management (that is, planning, prioritising and scheduling of work) process as one of its pillars is critical to ensure that the maintenance objective is reached. The successful implementation of TPM and involvement and buy-in of all role-players, including all departments and specifically employees, will ensure that Matimba operations are effective and successful.

1.2 PROBLEM STATEMENT

The problem of equipment and plant maintenance management is continuing to play a critical role in Eskom due to present generation (supply) capacity constraints and under-investment during the last twenty years. This is affecting the business operations of Matimba and Eskom with reduced revenue, escalating costs and, ultimately, profitability.

The power station as a business operation, with highly capitalised assets, needs continued maintenance of those assets to prolong the assets in order to sustain or prolong the lifespan of those assets for effective operations. The integration between different departments within the power station poses a challenge to Matimba's effective operations. The implementation of work management (which is a pillar of TPM) has not resulted in improvement in operational performance and is further evidence of a lack of proper consultation with key stakeholders like employees.

1.3 OBJECTIVES OF THE RESEARCH

1.3.1 Primary objective

Operational performance of Matimba Power Station has been relatively good, but the recent economic crisis is forcing companies to investigate its operational practices to ensure waste, non-value adding activities and costs go down. Maintenance department is the largest department and cost contributor in Matimba and other Eskom power stations, and new ways of operations need to be investigated. From an operations perspective, Maintenance cannot be viewed at in isolation; therefore, a systems approach is used to scrutinise other operational problems caused by other departments at Matimba.

The primary objective of this study was to investigate the way to ensure that the Matimba Power Station operates efficiently and effectively by proper maintenance management of the plant in the Power Station. This objective was covered mainly through the literature study in chapter 2 and recommendations to address the operations challenges posed in chapter 4.

1.3.2 Secondary objective

The evaluation of the preparedness of the Matimba Power Station to launch a TPM in order to enhance integration with other departments can result in continued operations success at Eskom power stations; and further than that, a culture and process of continuous improvement need to be instilled in Matimba to lead to long-term operational excellence.

The secondary objective of the study was to ensure that Maintenance takes the lead with the implementation of the TPM pillar (work management). Operations at Matimba will as a result be effective and the TPM process includes all role-players and all departments. Consequently, the lessons learnt at Matimba, as a result of the study, will be investigated for possible implementation at all Eskom power stations.

1.4 SCOPE OF THE STUDY

The scope of the study involved a literature study which included investigating the operations and challenges at Matimba Power Station, studying the operations management philosophies and employee involvement in operations, the maintenance management philosophies and the TPM.

The empirical study was based on the implementation of TPM (work management) and the involvement of employees in the operations change initiatives. Recommendations included the systems approach to address the operational challenges at Matimba Power Station.

1.5 RESEARCH METHODOLOGY

1.5.1 Literature study

The theoretical study was based on operations management, maintenance management and TPM. The primary sources of information for the research was Eskom Generation intranet, internet, books, journals, magazines, and personal work experience on operations management, the supply value chain, procurement and plant maintenance. The information was scrutinised and evaluated to reach a conclusion about operations management, maintenance management and TPM charting the way forward for Matimba Power Station.

1.5.2 Empirical study

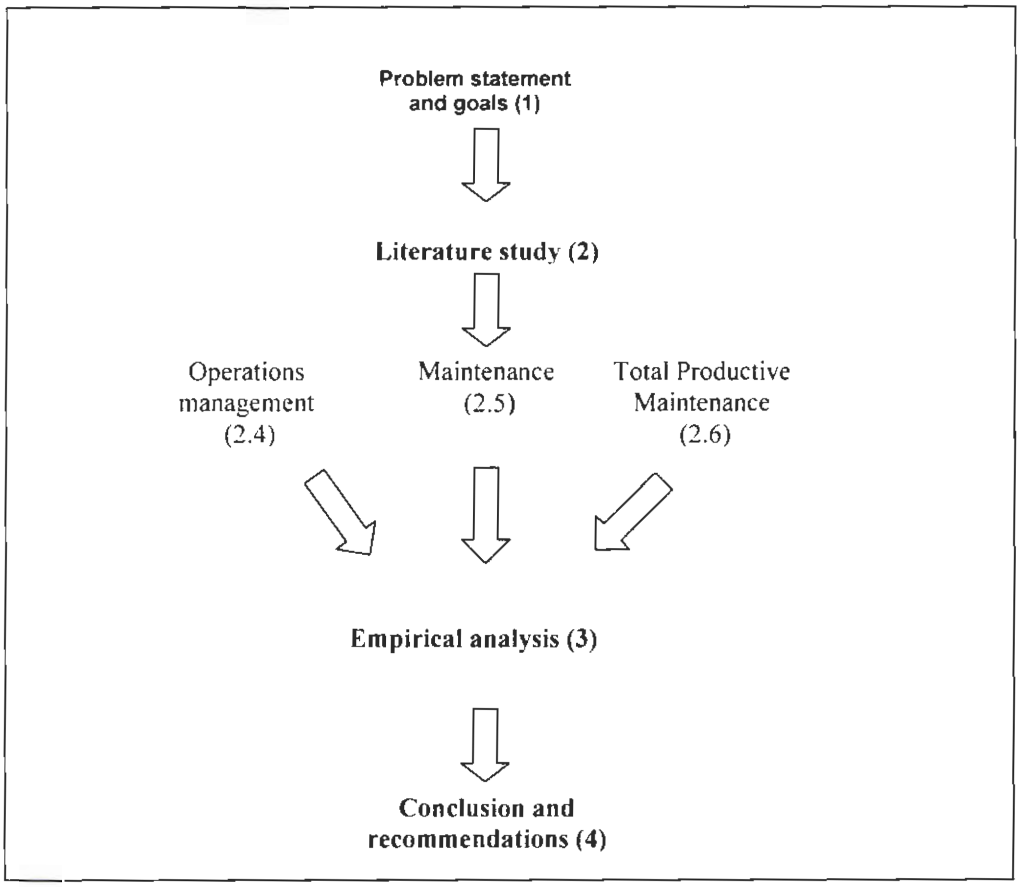
A survey in the form of a questionnaire was employed to understand the impact of Maintenance Work Management (a SAP preventative management system) on effective operations at Matimba Power Station, and also an understanding of TPM for possible implementation at Matimba Power Station. The type of statistical analysis done was mainly descriptive in nature. The mean values, the standard deviation and the test of significance were done in the analysis. The evaluation of the preparedness of the Matimba Power Station to launch TPM in order to enhance integration with other departments can lead to continued operations success at Eskom power stations. Further than that, a culture and process of continuous improvement need to be instilled in Matimba to lead to long-term operational excellence.

1.6 LIMITATION OF THE STUDY

The ethnographic research, that is, use of observations and interviews (problems with bias and subjectivity) was a limit as the author is an active participant in operations at Matimba Power Station.

1.7 LAYOUT AND STRUCTURE OF THE STUDY

Figure 1.1: Study process layout (flow)



(Source: Adapted from Ferreira, 2004)

The nature and scope of work is dealt with in chapter 1. The problem description and identification are explained and also the objectives and scope of the study. The research methodologies which include the literature study and empirical analysis are explained in the chapter. The limitation and layout and structure of the study are the last items in chapter 1.

The literature study is dealt with in chapter 2. This chapter deals with the operations management literature and possible applications thereof at Matimba Power Station.

Chapter 3 is divided into the research methodology and results. The chapter explains how the research has been done, and then moves on to present the results obtained via the empirical research.

Chapter 4 is the final chapter. It draws the conclusions from the research, and poses recommendations based on the research conducted.

1.8 SUMMARY

Chapter 1 provided an introduction to the study. It described the problem researched, the research design and also a limitation of the study. The next chapter provides the literature scrutiny of the study, laying the foundation for the empirical study, as discussed in the third chapter.

CHAPTER 2

LITERATURE STUDY

2.1 INTRODUCTION

The most important factors for effective and efficient operations are employee involvement and productivity, maintenance management and quality control (Gaither & Frazier, 2001:660).

The three factors listed feature prominently in the literature study. The literature study also concentrates on new thinking in operations management, starting with definitions and a brief overview of Matimba operations structures, processes and challenges. The general operations management philosophies that include quality, productivity, integration, employee involvement, maintenance (including types, tools and methods thereof) and TPM, together with its five pillars, are discussed to get a broader understanding of operations issues at Matimba Power Station. The chapter will end with a discussion of the work management pillar and its implementation at Matimba Power Station.

2.2 DEFINING OPERATIONS MANAGEMENT

Gaither and Frazier (2001:6) define operations management as the management of the organisation's productive resources or its production system, which converts inputs into the organisation's products and services. A production system takes inputs – raw materials, personnel, machines, buildings, technology, cash, information and other resources – and converts these into outputs, products and services.

Operations management is defined by Chase *et al.* (2002:6) as the design, operation, and improvement of the systems that create and deliver the firm's primary products and services.

In addition, Heiser and Render (2006:4) define operations management as the set of activities that creates value in the form of goods and services by transforming inputs into outputs. Adendorf *et al.* (1999:2) define operations management as the management of the direct resources necessary to create the products and services supplied or provided by a business.

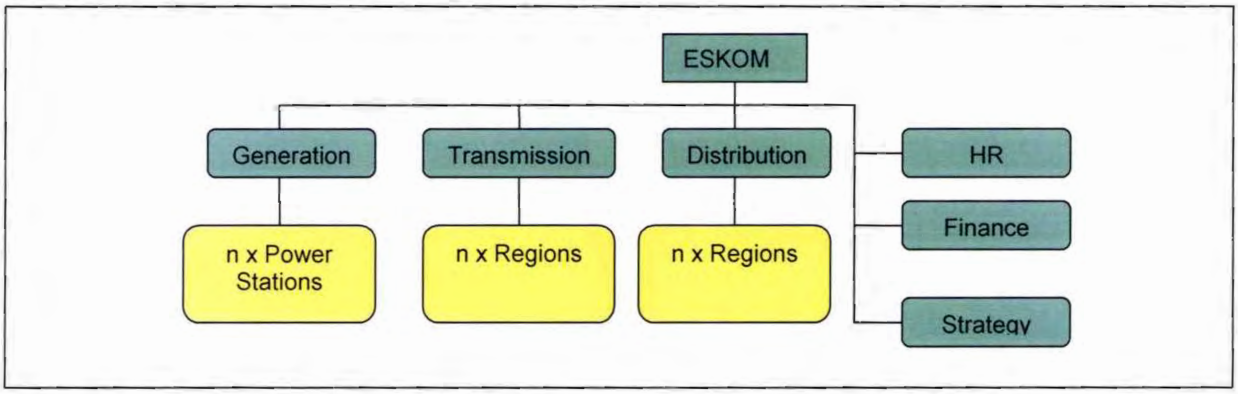
All the competing companies produce or deliver services by adding particular value to a service or product. The main difference may be the cost, quality, functionality, brand and looks (image) of the product or service delivered. Challenges within the business environment are immense, and competition is severe. Merely manufacturing and providing goods and services are no longer good enough. Operational efficiencies and effectiveness will determine whether organistions are in business tomorrow or not.

2.3 BRIEF OVERVIEW OF MATIMBA OPERATIONS

In a larger Eskom corporate structure, Matimba Power Station falls under the Generation Division as indicated in Figure 2.1. Matimba is a six pack (six units) power station which started commercial operations in 1984 when the first of the six units was commissioned. Each Matimba unit generates 665 MW which totals 3990 MW for total Matimba generating capacity.

Matimba Power Station is a flagship within Eskom Generation Division's fleet of power stations as a result of outstanding performance over the last four years. Matimba is the lowest cost producer of electricity within Eskom at R18.7/MWhr while the second lowest power station was at R24.20/MWhr (refer to figure 2.9). It also has the highest power send-out for consumption at 29 000 GW units in 2008. The annual send-out power from Matimba amounts to approximately 24,000 GWh. Matimba is the holder of the world record of 80 days for six units on load.

Figure 2.1: Eskom divisional structure

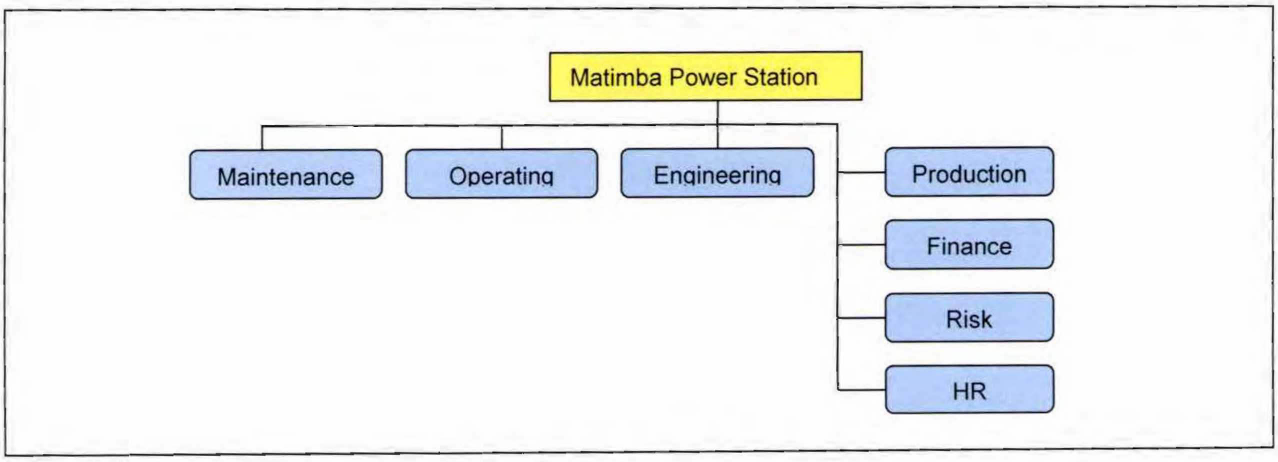


Matimba Power Station's budget for last year (that is, 2008 financial year ending in March 2009) was R519 million. Manpower numbers for the station were 609 employees at the end of the 2008 financial year. Maintenance department, being the biggest department with a budget of R278 million (in the 2008 financial year) with manpower numbers of 230 employees (by 2008 year end), is a critical department for successful business operations within the Power Station.

2.3.1 Structures and responsibilities at Matimba

Structurally, the Power Station Manager is accountable for overall operations management activities and his direct reports (Maintenance, Engineering, Operating, Finance, Human Resources and Risk Managers) are responsible for their respective departments. He is the Business Unit (BU) Head. Three production managers do not have departments and also report to the Power Station's manager. Their role is to coordinate production issues. The three technical departments (Maintenance, Operating and Engineering) are the main pillars of the Power Station.

Figure 2.2: Departmental structures in Matimba Power Station



Different departments (and their Heads of Departments) at Matimba Power Station have different responsibilities as specified in the station responsibility matrix.

❖ **Matimba maintenance department responsibilities**

The Maintenance department is the biggest department in the Power Station with more manpower and more budget allocation. As compared to Matimba Engineering department, which prescribes "What and When" to maintain, Maintenance department determines "How" to maintain the plant. Its responsibilities include:

- Work planning and scheduling for plant maintenance;
- Execution of all maintenance (corrective [unplanned], preventative [planned], statutory, and more) with all quality control measures (1st line, 2nd line and specialist maintenance);
- Determining spares and accountability for Plant spares holding;
- Planning and management of General Overhaul (GO);
- Provision of Plant work history for Engineering to do plant analysis
- Custodian of SAP PM module;
- Development and management of maintenance procedures and standards; and
- Safety of the Power Station as the supervisor of machinery in terms of the Occupational Health and Safety Act 85 of 1994 (General Machinery Regulation 2.1 (GMR 2.1) (South Africa, 1994).

❖ **Matimba operating department responsibilities**

The second biggest department at Matimba after Maintenance is responsible for operating the Plant, cleaning, water management and chemical process management (including the laboratory). This department's duties include:

- Responsible for daily 24 hours operation of the plant;
- 1st line maintenance (inspections);
- Custodian of OpsLog system (tracking of daily plant performance) and Occurrence Management System (OMS) (incidents recording);
- Plant re-commissioning and routine testing;
- Development and management of plant operating procedures and standards; and

- Plant cleaning, isolations and issuing of permits to work.

❖ **Matimba Engineering department responsibilities**

Engineering department is responsible for medium to long-term asset care (asset lifecycle management) and is also a custodian of the modification and design of the Plant. Its responsibilities include:

- Analysis of performance of the plant components, systems and management Long-term Plant Health (LTHP) indicator;
- Optimisation of technical and economical performance of the Plant;
- Development of optimised maintenance philosophy and strategies;
- Development of GO scope of work for long-term planned outages;
- Technical specification of plant, components and codification of plant;
- Investigation, motivation and management of modification;
- Root cause analysis of plant failure;
- Update of Life of Plant Plan (LOPP) and Technical Plan;
- Define Operating Technical Specification (OTS) maintenance specification of Plant; and
- Plant performance and testing.

❖ **Finance department responsibilities**

The finance department is responsible for finance management at the Power Station. The Eskom Electricity Generation license, issued in terms of the Electricity Regulation Act (No.4 of 2006) (South Africa, 2006), requires that the licensee (in this regard Eskom), shall keep separate financial records for each of its Generating Power Stations in each and every financial year comprising:

1. A balance sheet;
2. An income statement; and
3. Accounting notes to financial statements (in appropriate detail the amounts of any revenue, cost, asset, liability, reserve or provision which have been charged from or to any other business, together with a description thereof).

Other finance responsibilities include material management and supply chain management.

2.3.2 Processes at Matimba

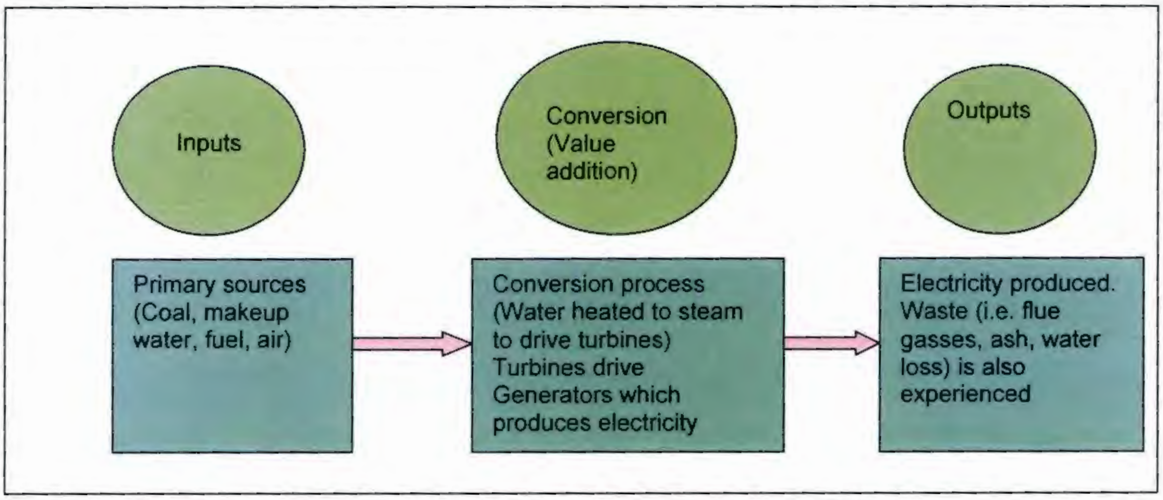
Matimba Power Station technical operations/processes involve the movement of coal (logistics) from Groot Geluk mine to Matimba Power Station through a system of conveyor belts which is between a distance of 10.7 km and about 12 km long (average distance between the mine and Eskom Matimba boilers). Air is also sucked into the boiler for pushing coal into the boilers and aiding the combustion process in the boilers. Oil and LP gas are also used for the initial combustion process. Water is used for the heating process and cooling. Water is heated in the boiler to produce steam which is used to drive the turbines. The rotating turbines will turn the generator rotor which will transform mechanical energy (turning rotor) into electrical energy for usage by the customers. The process of generating electricity also creates waste like ash, dust, smoke, and more.

Ash is also removed through the conveyor belts to the ash dump, which will be rehabilitated with top normal soil and trees planted on. All these processes involved in generating electricity need systematic inputs from different quarters like maintenance, operating, engineering, contractor, finance, HR, risk, and suppliers to make Matimba operations deliver on its mandate as per its Generating Licence requirements.

The success of an organisation (like Matimba) is the effectiveness of its operations management and processes which provide:

- Sufficient and skilful employees to serve customers (HR responsibility);
- coal supply to satisfy electricity demand;
- customers to consume electricity;
- appropriate quality of service;
- sufficient goods (electricity) to satisfy demand;
- a well designed work environment (workplace); and a
- continuous flow of ideas to improve its already impressive operations performance (Slack *et al.*, 1998:6).

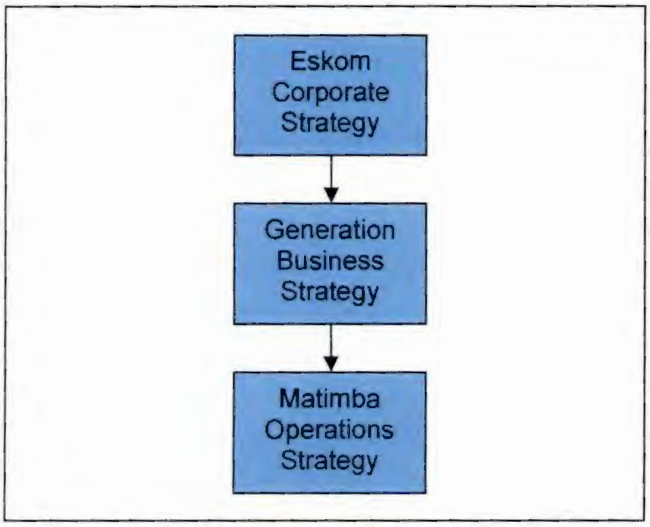
Figure 2.3: A production system model



(Source: Slack *et al.*, 1996)

Figure 2.4 indicates the process-driven philosophy of operations. Matimba is also following the same process. According to Adendorff *et al.* (1999:2), the business strategy, based on identified market demands, will determine the nature of the goods and/of services produced or provided by the business while the operations strategy deals with the choice of process by which the goods are manufactured or the services provided and also the necessary infrastructure to supply or provide the required products or services. Matimba's Operations strategy is based on the Generation Business strategy which also is based on Eskom's Corporate strategy structure as depicted in figure 2.4.

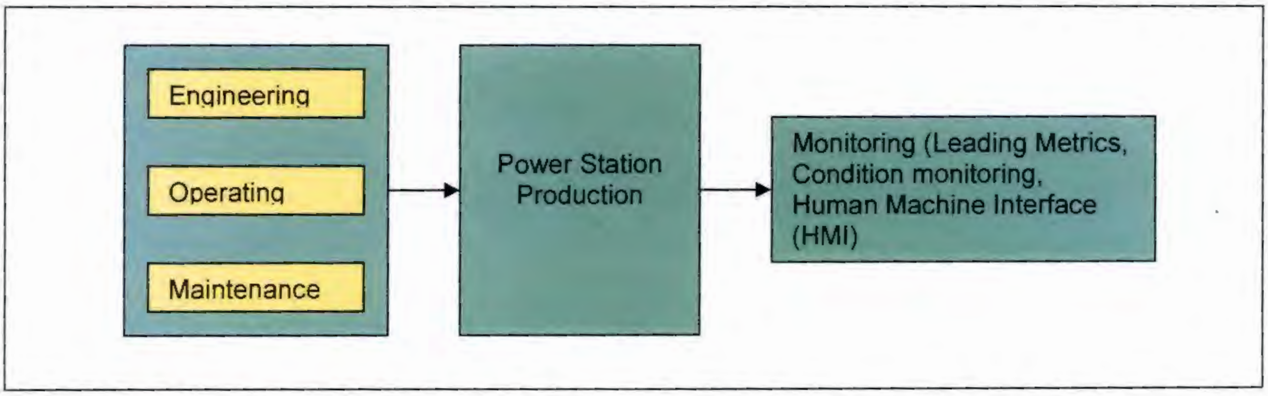
Figure 2.4: Matimba Operations strategy



(Source: Slack *et al.*, 1996:76)

Monitoring and process control in Matimba involves the use of a Human Machine Interface (HMI) system which is located at each unit. Other process control mechanisms like condition monitoring are also present within Matimba. The status of maintenance and performance is being measured and controlled through the use of leading metrics from the SAP PM system as indicated in figure 2.5.

Figure 2.5: Process control at Matimba



2.3.3 Operation challenges at Matimba

At present, Matimba faces a number of operational challenges that need management attention. The low quality and wetness of coal is one dominant factor in all power stations. A national decision made years ago when high quality coal (with low ash content) was exported and low quality coal (with high ash content) being utilised internally in the country had a negative operational impact on all Eskom power stations. More ash content means higher costs of environmental penalties, conveying and storage costs of that ash. The wetness factor of coal is a problem that has engineering solutions and it is a problem that can be solved.

Chase *et al.* (2006:474) indicate that inventory hides problems in operations. Low inventory levels will expose those problems. Just in Time (JIT) production is very important because it exposes deficiencies within operations. Gao (22:2007) asserts that there is always an inventory problem associated with maintenance management. He suggests, in support of Ram and Olumolade (1987), different inventory control models for PM problems.

Operations management (OM) issues like Supply Chain Management (SCM) (materials management, procurement) are one of the supporting processes that enhance a good maintenance management system. At Matimba, these processes have been listed as the one lacking in terms of supporting maintenance.

Problems always come up at functional level when there is interfacing between the departments (SCM being the responsibility of the finance department). There was initiative from Eskom to centralise the procurement of strategic services and spares, but this is running into problems.

Presently, spares stock holding at Matimba Power Station alone is R157 million. The maintenance staff is also keeping pirate (bush) stores that are not allowed. There are also problems with material management, for example, wrong spares (accuracy), and low stock turn. There is also the problem with Power Stations' strategic spares. The original design of power stations was to ensure sharing of these strategic spares.

These problems have been looming for years and no solutions have been found. The Eskom Board is busy with the proposal that materials management (MM) should fall under Maintenance department structurally. This means that the Maintenance department instead of Finance department will be responsible for one part of SCM. What is critical is that the decisions taken need to highlight the fact that what is good operationally, may not be as good, strategically. Will this lead to effective operations at Matimba Power Station?

One problem that the Eskom Board is investigating is the procurement side of the business. There is a huge support for centralising procurement to ensure that co-ordination and the overlapping of responsibilities are eliminated. Also, there is a move to decentralise coal procurement. The coal procurement done at Power Station (decentralisation) will change the operations management profile at the power stations.

The stock-out problem is another factor that does not help maintenance. Holman and Buzek (2009:1) define out-of-stock as being any condition that prevents the consumer from purchasing a product and leaving the store without making a purchase of that product. That includes: The shelf is empty; the consumer saw the item, but it was locked, or the consumer could not procure the item as there was no help available, the consumer found someone to help, but they could not find the item, the price/offer on the shelf did not match the advertisement or online price. This broad definition shows that the SCM employees (under the Finance department at Matimba) should do more to ensure that the item is ultimately in the hands of the consumer/client. The supply chain problems are also numerous and need special research, and will not be dealt with deeply in this study.

2.4 OPERATIONS MANAGEMENT

An earlier description of operations management confined this management science mainly to the manufacture of physical products or goods; hence, it used to be termed production or industrial management (Adendorff *et al.*,1999:2).

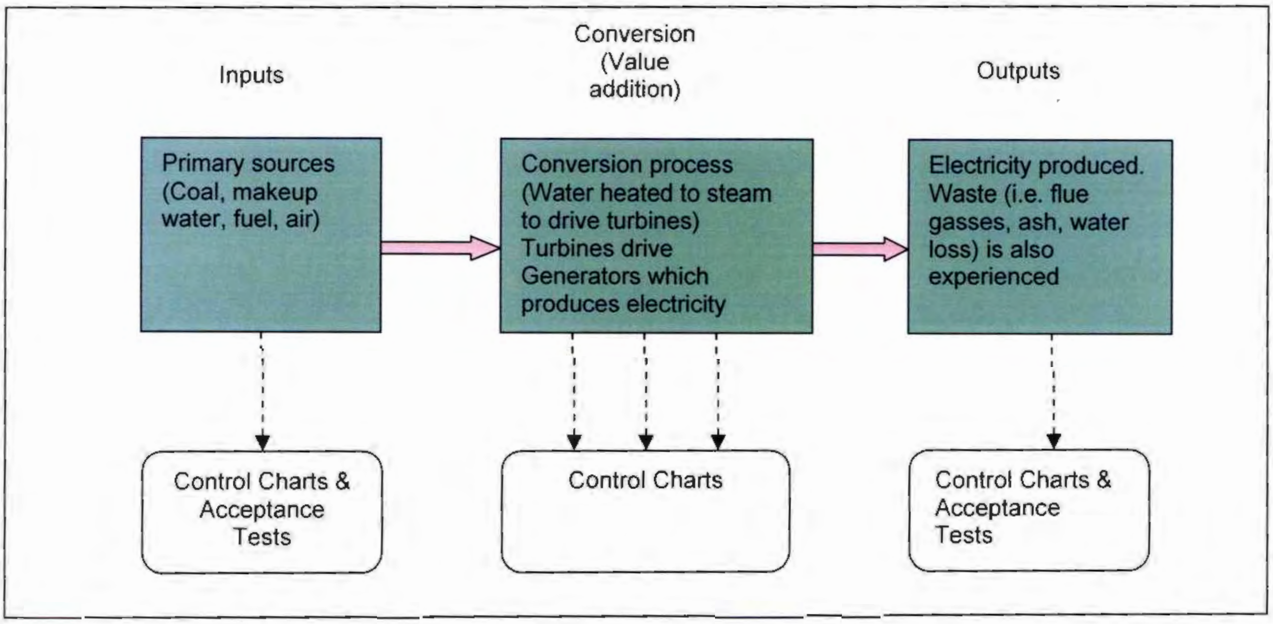
This view limited operations management thus excluding services in a world increasingly being taken over by the services industry. New sciences like knowledge management (mainly driven by the booming service industry with the intention of harnessing the intellectual capacity of a company) and TPM ensure that a new way thinking emerges in operations management.

Successful operations are the ones that have implemented effective quality controls, productivity targets, departments' integration, maintenance management, and employee involvement in operations. This chapter focuses on these five identified factors.

2.4.1 Quality control

According to Gaither and Frazier (2001:661), to maintain effective and efficient operations, companies should have, among other important things, quality controls in place.

Figure 2.6: Quality control throughout production system



(Source: Gaither & Farzier, 2001:664)

Gaither and Frazier (2001:665) suggest the following inspection principles are used for quality control in production and operations because of its economic validity:

- Inspect after operations, that is likely to produce faulty items;
- Inspect before costly operations;
- Inspect before operations that cover up defects;
- Inspect before assembly operations that cannot be undone;
- On automatic machines, inspect first and last pieces of production runs, but few in-between pieces; and
- Inspect finished products.

The perspective on quality management, as indicated in figure 2.6, is that quality needs to start from the very beginning of the production process to eliminate any waste or rework that may accumulate upstream in the process.

World-renowned philosophical leaders of the quality movement (Crosby, Deming and Juran), all concurred that Total Quality Management (TQM) is a continuous process and not an event, and teamwork is very important to achieve operational goals (Chase *et al.*, 2006:321).

Although the Engineering department at Matimba has produced the Process Quality Plan (PQP) and Quality Control Process (QCP) procedures for the station, the quality structures have not been in place and quality management responsibility lies with risk management which, according to many managers at Matimba, is a misallocation of responsibilities. This can be attributed to management focus not being quality conscious.

2.4.2 Production and productivity within operations

As the competition between companies becomes fiercer, companies are seeking ways to cut production costs. Unit costs are cut by increasing productivity while resources used for production decrease or remain the same. According to Gaither and Frazier (2001:698), most companies have installed capital equipment (new automation technology) as a substitute for labour to be more productive.

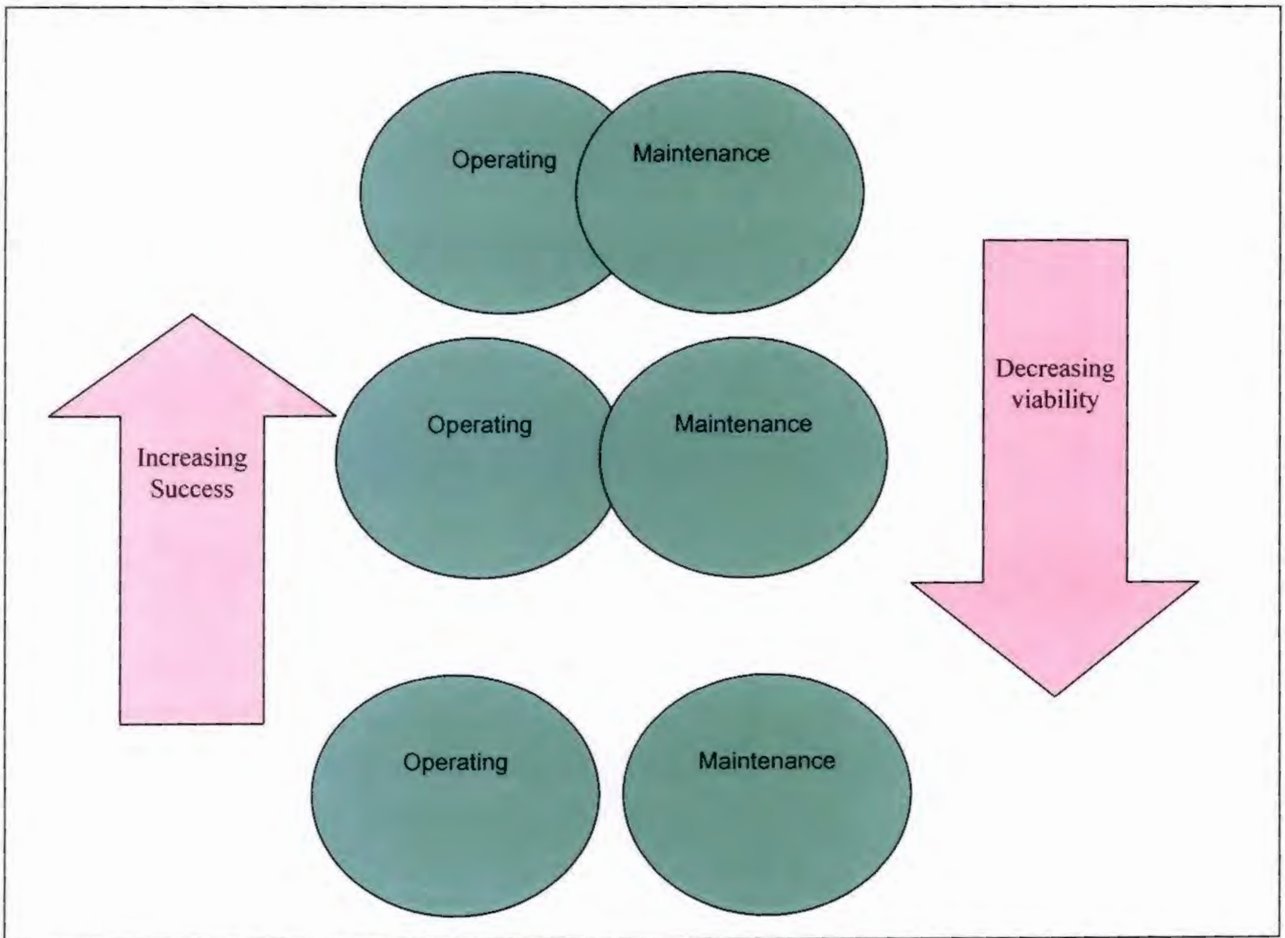
Matimba productivity (and general productivity in South Africa) is a great cause of concern. The number of public holidays, and inflexible labour laws have been quoted by many economists as doing disfavour to the country. Internally in Matimba (and at Eskom in general) many activities are done manually through labour whereas advanced technology is available. For example, at Matimba stores, inventory management and counting are done manually, while scanning technology and Radio Frequency Identification (RFID) technology can reduce labour utilisation by huge numbers thus reducing costs to the Power Station.

2.4.3 Departments' integration within operations

Matimba Power Station cannot function without the three legs of operations management (i.e. engineering, operating and maintenance) and a close working relationship of these three is critical. Muhleman *et al.* (1992) emphasise the importance of closer integration of departments within a business operation, as indicated in figure 2.7.

The ultimate goal of any business operation is to make money through customers' interest or need for the products the business operation offers. Through marketing, the business displays its products and creates a need for them. Willmott (2008), in figure 2.3, explains the integration of marketing, production and maintenance within a business operation as critical to ensure that a business's ultimate goal is achieved.

Figure 2.7: Effects of separating functions in production environments



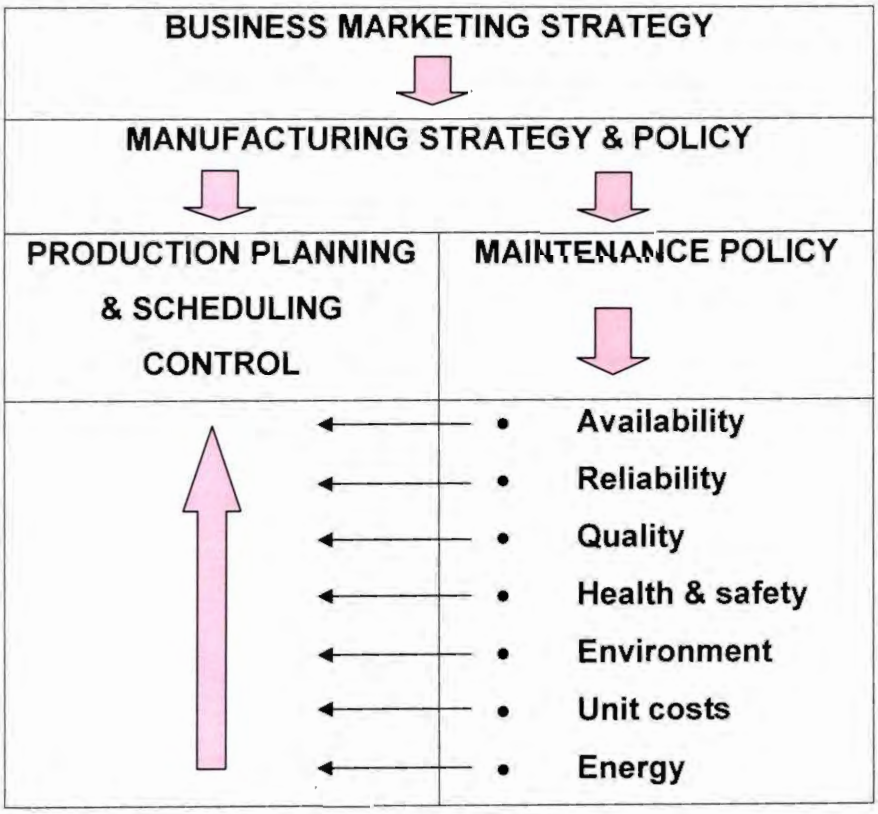
(Source: Muhleman *et al.*, 1992:7)

The idea of bringing closer the different departments/functions is to ensure closer understanding and alignment between the departments. Managers need to ensure that closeness does not result in total takeover where focus is lost. They need to manage the relationship.

According to Rich and McCarthy (2008), experience has shown that maintenance sections closer in terms of working relations to production, do better than those which are less close. This leads to more respect and more involvement in broader production issues. The sections that are closer to production show more ownership when things go wrong. When lean manufacturing is introduced, these sections are more fully involved in the program and naturally take the lead when dealing with technology to improve processes, leading to increased quality, less cost and enhanced performance.

Heiser and Render (2006:656) list the interdependency of operator, machine and mechanic (artisan) as a hallmark of very successful maintenance, reliability and operation.

Figure 2.8: Integrating maintenance with production



(Source: Willmott, 2008:26)

The same integration analogy that exists between the Maintenance, Operating and Engineering departments is very important for Matimba to realise its ultimate goal.

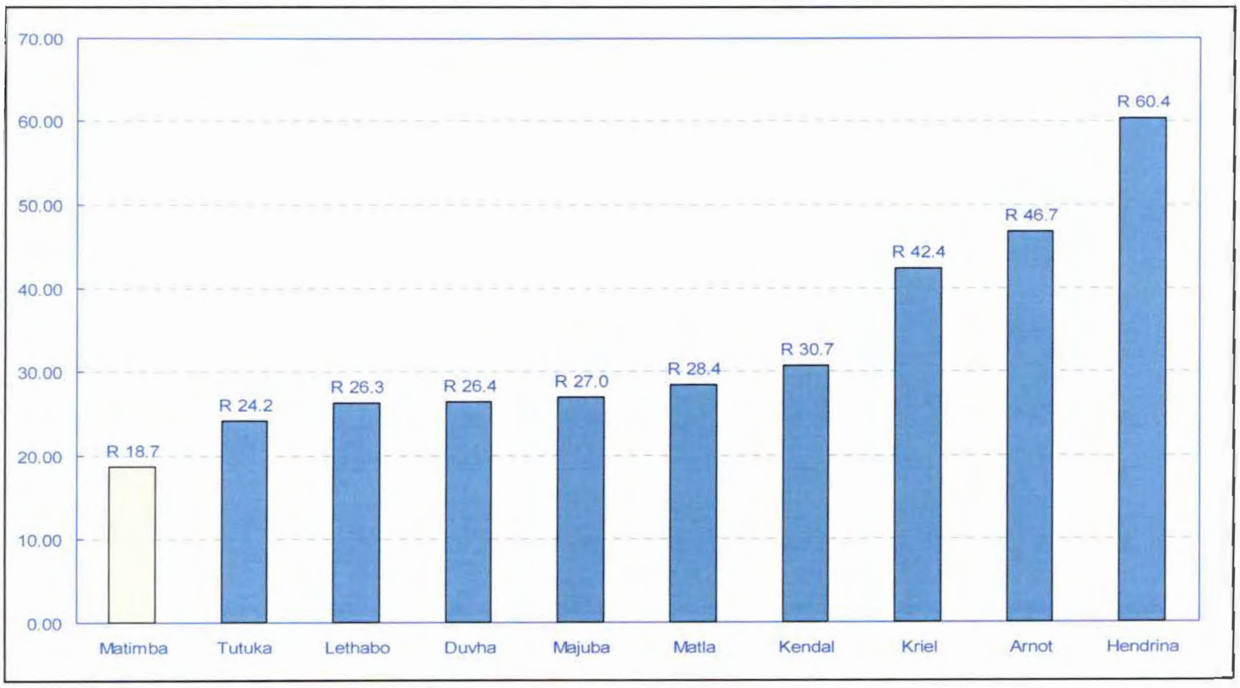
2.4.4 Maintenance management within operations

The maintenance management (mainly preventative maintenance) cost escalations has forced many companies to re-look at ways to increase effectiveness and efficiencies at reduced costs within operations like Matimba Power Station.

Heiser and Render (2006:660) list maintenance management as one of the most important contributors to effective and efficient operations. Maintenance of production equipment, assets and facilities is another important aspect of controlling costs and quality. Adendorff *et al.* (1999:315) state that the mismanagement of maintenance can lead to catastrophic consequences for an enterprise. This includes threats to safety, to plant, lower quality products and services, lower customer satisfaction, and more.

2.4.5 Operations performance

Figure 2.9: Comparison of Eskom power stations' operating costs in R/MWh



2.4.6 Employee involvement in change initiatives within operations

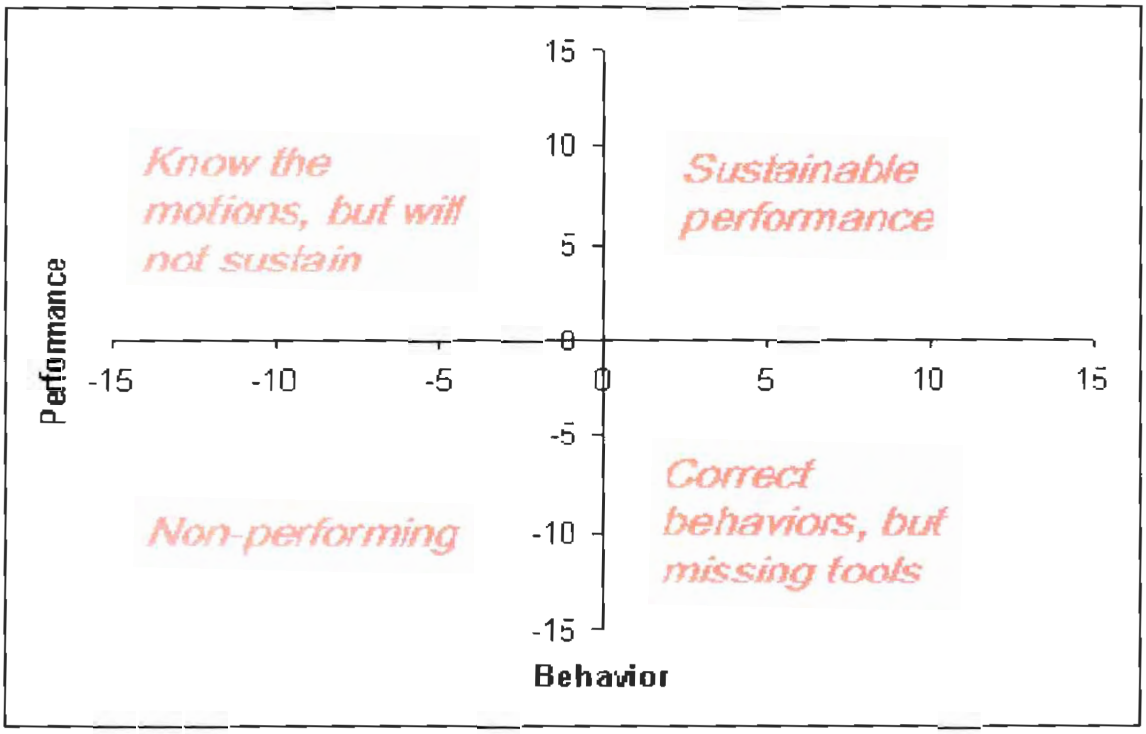
Different studies have proven a link between employee satisfaction, customer satisfaction and profitability of an enterprise. Watson's (in Rollins, 2003) worldwide study found that maintaining an involved and satisfied workforce leads to improved performance resulting in financial gain. Rollins (2003) supported the idea of employee involvement with his studies on employee involvement on change initiatives.

Wanner emphasises the importance of information in a human mind. He stated that an absence of information is felt as unpleasant by the human mind. In the absence of information, the human mind creates something new by thinking of something else, thus separating himself from the process he is supposed to be tending (Villemeur, 1991:411).

According to Chase *et al.* (2001), the cornerstone of TPM programs is worker involvement and information sharing. The reasons for keeping equipment in perfect operating condition are not only to avoid interruption to production, but also to keep production costs low, keep product quality high, maintain safe working conditions, and avoid late shipments to customers.

Army (2008) emphasised the importance of employee involvement on change initiatives, by saying times have changed significantly and that behaviour change is now recognised as a key contributor to the success of any process initiative. He indicated that modified and new behaviours (figure 2.10) are the key to any change initiative success. Matimba management should have considered measuring the success of a work management change initiative through an employee survey.

Figure 2.10: Behaviour/Performance matrix



(Source: Army, 2008)

Levery (2008:6), in his study of maintenance personnel's attitudes, found a belief that planned work is boring and craftsmen would rather prefer a technical challenge of sorting out a problem, and that this indicate the behaviour pattern that needs changing.

Rich and McCarthy (2008) identify two common causes of breakdowns as equipment and human error (table 2.1).

Table 2.1: Improving MTBF (Delivering zero breakdowns)

	COMMON CAUSES OF FAILURE	PREVENTION ACTIVITY
HUMAN ERROR	Dirt, blockages, surface damage and foreign matter	Cleaning, eliminating the sources contamination, stopping the scattering of debris
	Contaminated or improper lubrication	Daily lubrication, measurement of heat generation and vibration
	Excess play and leakage due to looseness of parts	Regular tightening and use of match marks
EQUIPMENT CONDITION	Wear and corrosion	Measuring thickness and vibration
	Breakage and fatigue	Visual checks and stress analysis
	Deformation and warping	Tolerance controls

(Source: Rich & McCarthy, 2008)

Heiser and Render (2006:656) highlight the importance of employee involvement for operations success when they list a reward system, skills training, information and power sharing as critical factors for operational success. According to Liker and Meier (2006:6), Toyota has one of the most stable workforces in the world because one of its operations philosophies is respect for humanity. They believe that it adds value to the organisation by challenging its people and partners to grow. Toyota Production System (TPS) used to be called the "respect for humanity" system. Respect for humanity creates a stress-free environment that provides lots of amenities, but many of the tools of TPS aim to raise problems to the surface, creating a challenging environment that forces people to think and grow. Thinking, learning, growing and being challenged are not always fun. But in a challenging environment, people grow and become more confident.

The long-term behaviour change initiative from management at Matimba will ultimately result in a change of culture which will enhance operational performance. Many change management initiatives fail due to non-commitment to a long-term change strategy. The challenge facing Matimba presently is the non involvement of employees in important change initiatives like improvement of operations performance. One of the objectives of this study was to prove if the present change initiative involved workers and whether it is accepted.

2.5 MAINTENANCE MANAGEMENT

Wilmott (2005) highlights the importance of production asset care (maintenance) by stating that manufacturing excellence is good only if availability, reliability and predictability of the manufacturing assets are good. For improvement of maintenance performance, a correct mix of various improvement tools, techniques and service providers need to be in place. The maintenance role in power stations' operations is slightly different as compared to other industries, because an intangible product (electricity) is created (unaccustomed customer only realises its presence and quality by its effects).

2.5.1 Definitions

Corder (1976) defines five key objectives of maintenance as follows:

1. To extend the useful life of assets;
2. To assure the optimum availability of installed equipment for production and/or services, and obtain the maximum possible return on investment;
3. To ensure readiness of equipment needed for emergency use at all times;
4. To ensure the safety of personnel using facilities; and
5. To guarantee customer satisfaction.

Patton (1988) lists major work tasks to be accomplished in any maintenance environment as including: inspection, replenishing consumables, troubleshooting, removal and replacement, repair, adjustment, calibration, functional testing, refurbishing, and conditioning.

Maintenance management is defined as an organisational function of planning, organising, directing and controlling activities applicable to maximising time, money, personnel, equipment and materials that are directed toward the upkeep of an organisation's total facility, equipment, services, buildings, and so forth (Kruger *et al.*, 2005:216).

Eskom Generation's definition of maintenance management states that all activities of management determine the maintenance objectives, strategies and responsibilities, and implements them by means such as maintenance planning, maintenance control and supervision (work management and control), and improvement of methods in the organisation including economical aspects (Anon., 2007a).

McCall (1965:499) defines PM as the performance of maintenance activities before failure occurs. He also defines corrective maintenance (CM) as the performance of maintenance activities when failure has occurred. The general consensus among maintenance experts is that PM activities include inspections, replacements and scheduled repairs.

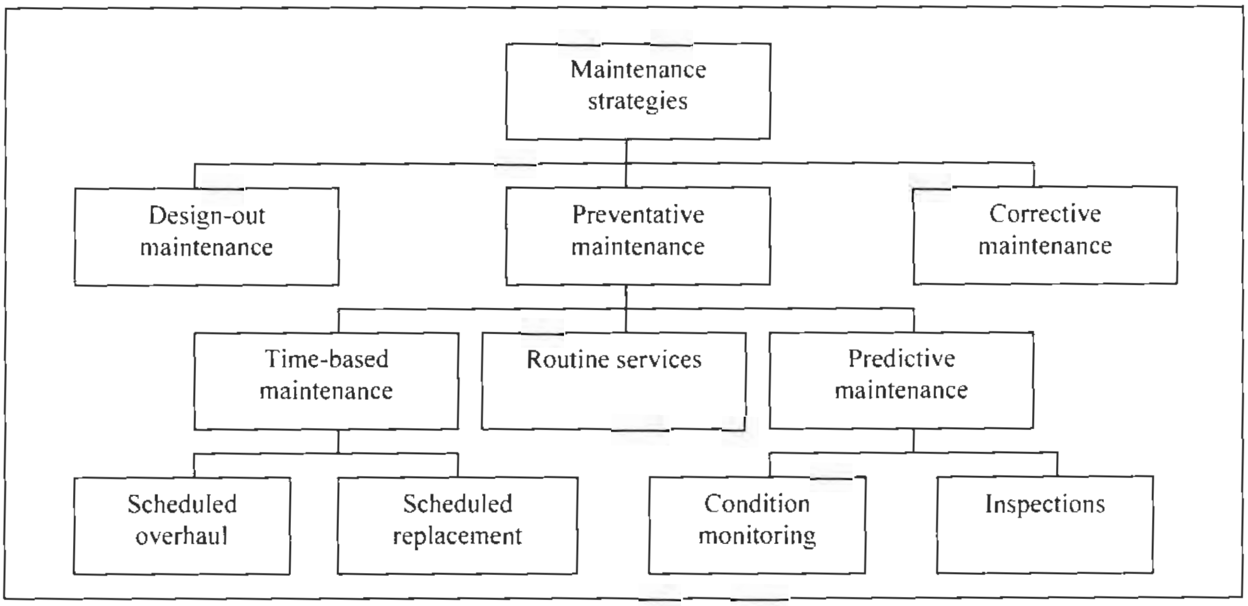
Design-out maintenance is, according to GGD 1447 (Eskom document – reliability basis), the inspection and maintenance tasks required to prevent the system or component from affecting the Plant reliability. Engineering departments within power stations are responsible for the reliability basis (refer to figure 2.12).

2.5.2 Types of maintenance programs

Different types of machinery and equipment demand different approach of maintenance, and by distinguishing between the right maintenance types to use the maintenance and engineering personnel, end up developing the right maintenance strategies to use for different type of machinery.

Gaither and Frazier (2001:743) make a distinction between the costs of repair and PM activities. They list repair as work done after breakdown or after a machine has failed. It is reactive, and PM is the regular scheduled work done to avoid breakdown (downtime) of production assets like production machinery and equipment before failure. This schedule can be after one month, one year, three years or five years, or after so many operations.

Figure 2.11: Different types of maintenance strategies



(Source: Coetzee, 2000:2)

Coetzee (2000) describes different strategies as:

- **Preventative maintenance** is maintenance of an item performed to prevent failure of an item.
- **Corrective maintenance or failure** (wait for failure). Reactive in nature is maintenance of equipment after it has failed. The run-to-failure strategy is used in equipment that is cost effective to let to fail before taking any action, for example, light bulb replacement.
- **Breakdown maintenance** is corrective maintenance of a failed item normally subject to, or which should have been subject to, preventative maintenance.
- **Condition-based maintenance** is preventative maintenance of an item performed when a measurable condition of that item indicates that maintenance is necessary to prevent failure of the item.
- **Scheduled maintenance** is preventative maintenance of an item performed at fixed time intervals, or at intervals determined by the extent to which the item has worked.
- **Run-to-failure** is failure of an item, which has intentionally not been subjected to preventative maintenance.

- **Predictive maintenance or condition-based maintenance**. The condition of equipment is measured or monitored.

According to this policy, the choice of maintenance shall be selected so that the following requirements are met:

- All legal and statutory requirements;
- Customer requirements;
- Sum of lifecycle costs of equipment is minimised;
- Eskom requirements on environment;
- Eskom requirements on risk;
- Eskom requirements on quality; and
- Eskom requirements on standardisation.

The cornerstone of the Eskom generation (Matimba) maintenance philosophy is the PM, like in many organisations, because of the nature of Eskom's business and the benefits being brought by PM.

2.5.3 Tools and systems used for maintenance management

The MMIS system (SAP PM) the Generation group is using is embedded within the ERP system (SAP). The use of SAP PM in Generation is presently limited to maintenance work management; the resource cost recovery part of the system is presently not used optimally.

The use of the Computerised Maintenance Management System (CMMS) which is a computerised maintenance work execution system helping companies/enterprises to manage work orders, material and purchasing, has made the maintenance management easier, as companies endeavour to improve its operations. The newer versions of CMMS also calculate the costs and repair history. The process, as a work order module, receives maintenance input, creates work orders and tracks work in progress (process). It also generates reports, like work status and equipment availability (Vineyard & Meredith, 1992:2649). The inventory module ensures that spares are kept sufficient and cost effective. It automatically generates reports and issues requisitions whenever quantities drop below a predetermined level (re-order point). A material reservation function additionally ensures sufficient stock is on hand for scheduled projects. The purchasing module generates purchase orders (POs) for stocked and non-stocked items, special orders and services. It tracks open POs and generates a list of those past due date. If buyers wish, they can access complete supplier and item order histories on demand (Stagnaro, 2001:105).

The SAP PM module is a CMMS used in Eskom Generation (including Matimba Power Station), and this module is part of larger SAP Enterprise Resource Planning (ERP) system used within Eskom.

According to Singer (2002:34), organisations had to make a choice between the best breed CMMS or software packages that address a multiplicity of business functions such as an ERP system like SAP.

In a value chain, process-driven organisations like Eskom Power Stations, a department cannot have a system that is stand-alone without integrating with other departments, thus the need for SAP. An ERP system with all modules include a finance module, SAP PM (Plant Maintenance) module, material requisition planning module, human resources module, and others.

The problem with a SAP ERP system is that it was initially a finance module with a SAP PM module, an add-on feature that was not initially included and it cannot offer better scheduling and dispatch functionality as pure CMMS systems like MAXIMO offers.

The traditional maintenance effectiveness measurements and KPIs used are:

- **Mean Time between Failures (MTBF),** which is the mean time that the system or equipment is in an operative state calculated over a given time period; and the
- **Mean Time To Repair (MTTR),** which is the mean of all time periods taken to repair and restore a failed system or equipment to an operative state calculated over a given time period.

Consolidating these KPIs per equipment to measure the overall maintenance performance was cumbersome in Matimba, and in many instances was not done. The new maintenance KPIs used to gauge the overall performance of maintenance as a business is already implemented at Matimba. These KPIs are explained further in section 2.4.4.2 under the work management pillar of TPM.

2.5.4 Current state of maintenance in Matimba

Matimba has a number of challenges of Plant failures particularly on the Ash and Coal plant. The Ash and Coal Plant stoppages resulted in spillages which increased the Plant cleaning costs. The number of plant stoppages was increasing and it has stabilised due to a maintenance task group formed to address this.

Boiler tube leaks (BTL) remain one of the main failures troubling all Eskom power stations. This problem is due to the high ash content of Eskom coal which rubs off the surface of the tube walls due to its abrasive nature. Matimba is presently the leader in terms of reduced number of tube leaks and other stations are copying what Matimba is doing: A monthly BTL meeting, where the maintenance and repair strategy of boiler tubes is discussed and implemented, is held.

As indicated in 2.3.3, high maintenance spare parts (high inventory) hide quality problems of maintenance. The cost of rework is due to high inventory levels. Maintenance and materials managers are looking at reducing the stock levels focusing on non-critical stock not used. The target set for 20% reduction is December 2009.

One of the most challenging problems with regard to employees at maintenance is a shortage of artisans. At the moment, experienced assistants (utility men) are doing the work supposed to be done by artisans, and labour colleagues (unions) are challenging maintenance management on this.

The recognition of prior learning (RPL) is presently investigated to ensure that the employees doing high level work are properly compensated. The employee relations improvement at Maintenance is an ongoing venture and problems are addressed at the Business Unit Forum which is a management and labour forum.

2.6 TOTAL PRODUCTIVE MAINTENANCE (TPM)

2.6.1 Definitions

TPM is a production-driven improvement methodology that is designed to optimise equipment reliability and ensure efficient management of plant assets. It is a method for bringing about change. It is a set of structured activities that can lead to improved management of plant assets when properly performed by individuals and teams (Robinson & Ginder, 1995:453).

Pomorski (in Chase *et al.,* 2006:470) defined TPM as a structured equipment-centric continuous improvement process that strives to optimise production effectiveness by identifying and eliminating equipment and production efficiency losses throughout the production system lifecycle through active team-based participation of employees across all levels of the operational hierarchy.

Lean manufacturing is defined in terms of waste. Waste, according to Toyota's president Fujio Cho, is anything other than the minimum amount of equipment, materials, parts, workers, and working time, which are absolutely essential to production (Chase *et al.,* 2006:472).

Taiichi Ohno (in Liker & Meier, 2006:33) explains the process of lean manufacturing by saying that, "All we are doing is looking at the time line the customer gives us to the point when we collect the cash. And we reduce that time line by removing the non-value adding wastes to the process."

2.6.2 Background information on TPM

According to Venkatesh (2009:8-10), the origins of TPM can be traced back to 1951 when PM was introduced in Japan (adapted from the United States of America). TPM started in Japan (to support the TQM strategy) under the auspices of the Japanese Institute of Plant Management (JIPM). The Japanese realisation was that companies cannot produce a consistent quality product with poorly maintained equipment. In the 1960s, JIPM established and awarded a prize to companies that excelled in maintenance activities.

The later idea of TPM evolved into a lean manufacturing philosophy which was championed successfully by Toyota (refer to Toyota article). Today, because of successful results of Japanese companies, many countries are implementing the TPM. One of the cornerstones of successful implementation of TPM in Japan is respect and involvement of employees in the process of TPM (Anon., 2009a). Wilmott (2009) noted that TPM focuses on ensuring that maintenance activities that are carried out on the equipment are performed in a way that is cost effective. The goal of TPM is important to lowering of cost of maintenance. Planning, scheduling and backlog control are all critical to ensure that the low cost maintenance goal is achieved and also ensuring that unnecessary downtime is to be avoided.

Equipment maintenance history is also important to ensure that decisions taken on equipment/plant design/purchasing is based on performance history of that particular equipment/plant. Standardisation of equipment based on historical data also enhances the plant performance. Inventory and spares holding costs can also be minimised due to standardisation (low stock holding).

In 1960, Nippondenso, which is the first Japanese company to introduce the concept), realised that PM is becoming a problem as more maintenance personnel were required and insisted that operators do routine maintenance. Equipment effectiveness was improved by modifying the plant and later quality circles were introduced. Due to these improvements, Nippondenso (part of the Toyota group), became the first Japanese company to receive TPM certification issued by the Japanese Institute of Plant Engineers (Venkatesh, 2009:13).

The procedures (including reliability centred maintenance (RCM)) are looked at, and its effectiveness in increasing the availability of equipment is assessed, and recommendations are made. The idea of TPM is to eliminate waste within operations. The philosophy of waste elimination has made Toyota the most profitable company in the world. For example, bringing parts to an assembly line every hour seems wasteful, yet it supports a principle of creating a flow. Liker and Meier (2006:36) hinted that spending time on developing consensus and getting input from those most affected seems wasteful, but by short-circuiting this process some of the time, you will short-circuit it most of the time. The aim of "flow" is to eliminate idle time in any work environment. Redesigning work processes to achieve "flow" typically results in products or projects being completed in one tenth of the time that was previously required. Flow is a key to a true continuous improvement process. Creating work load stability is also important to create continuous improvement. Peaks and spikes are levelled by bringing in contractors (flexible workers) who are shock absorbers (Liker & Meier, 2006:33).

At Matimba, too much waste (time and resources) is prevalent due to operators doing only lockouts and isolations, and artisans doing routine work and also more specialised maintenance. Much time can be saved by letting an operator to also do routine work. Many operators have long service doing basic routine work. At the moment, maintenance employees (artisans), after working, leave the workplace dirty expecting operators to clean on their behalf. The present management philosophy of Maintenance in Eskom, in general, needs to change due to ageing and an adverse operating regime for Eskom power stations that have changed dramatically (due low reserve margin, high continuous plant loading, wet coal, increased capital cost of new plant, and more) so the maintenance regime also needs to change and TPM will help for overall production improvement.

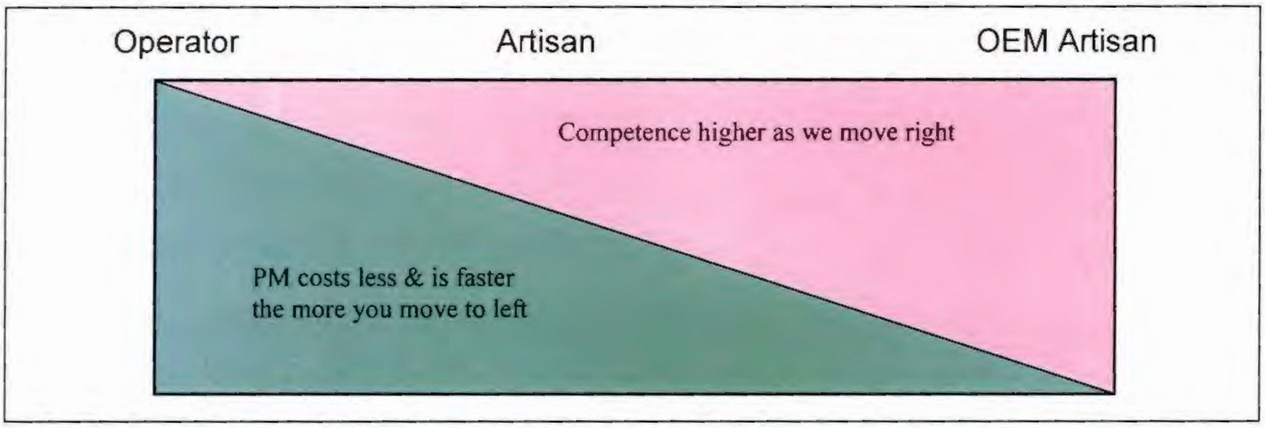
2.6.3 Pillars of TPM

Willmott (2008) stated that operational excellence cannot be achieved without operational basics being in place. It is also true with the implementation of TPM that needs the pillars identified to support it. The pillars are:

2.6.3.1 Autonomous maintenance (operator based maintenance)

According to Heiser and Render (2006:656), interdependency of operator, machine and mechanic (maintainer) is a hallmark of successful maintenance and reliability. Autonomous maintenance is the operator-based maintenance (1st line) done by the operating department in the plant. This is in support of the principle of leanness by eliminating time and labour wastage. According to Baber (2009:5), 40%-60% of unplanned failures can be eliminated by implementing autonomous maintenance.

Figure 2.12: Asset management process



(Source: Heiser and Render, 2006:663)

Figure 2.11 illustrates that operator based maintenance is cheaper and faster than the maintenance done by the artisan in the maintenance department.

Gao (2007:3) found that cross-training (multi-skilling) of employees to do PMs in order to improve productivity and cut costs, has not been extensively studied and can have challenges if not properly implemented. He suggests that employees need to be carefully selected for multi-skilling purposes. Moubray (2001:18) emphasises this point when he stated that successful, lasting maintenance can only be developed by maintainers and users of the assets (operators) working together.

In Matimba, operators identify a small fault, report or load a notification and wait for Maintenance to solve it. Losses like that that use two resources to solve a small problem, and equipment idle time are some of the losses incurred. Small non-intrusive and routine maintenance can be done by operators as they spend most of their time on the Plant. New stations like Medupi Power Station can implement it better by ensuring that outsourced Maintenance will focus on core issues.

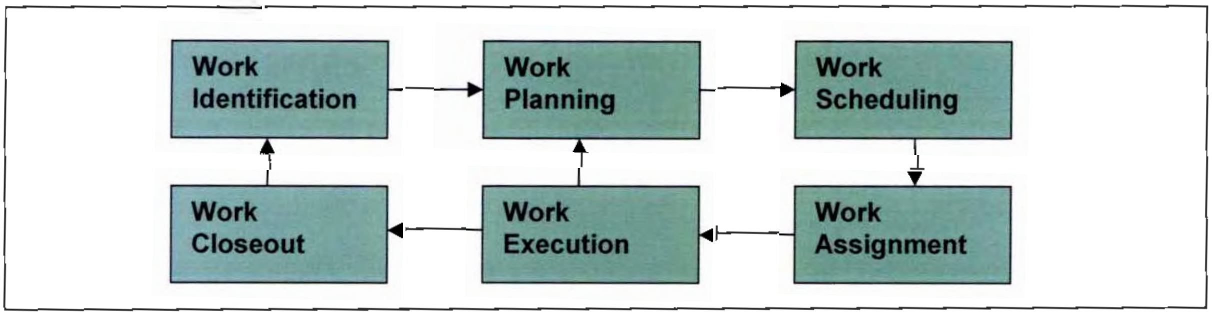
2.6.3.2 PM (work management)

PM is a cornerstone of work management which involves planning and scheduling of maintenance activities within a specified time in order to decrease unplanned components in maintenance. Mostafa (2004) defined PM as the practice that encompasses all planned, scheduled and corrective actions before the equipment fails. Kodali *et al.* (2008:123) describe PM as a major component in moving from reactive to proactive management through early detection and correction. Kodali (2008:124) also highlights inspection, which leads to early detection and early correction as the most important activity in PM and as the reason why most of the industry supports this philosophy.

Chase *et al.* (2006:481) indicated that PM is carried out by operators (and not maintenance personnel), because they are most familiar with their machines. A six-step process is currently in place to ensure that routine work management runs smoothly in Matimba and other Eskom Power Station.

This method is presently facing scrutiny due to cost implications. The main issues raised are the frequency of some of the activities which stop the normal running plant and at times introduce unreliability to the Plant reliable before, due to quality problems.

Figure 2.13: Six-step process for work management



(Source: Anon., 2007c)

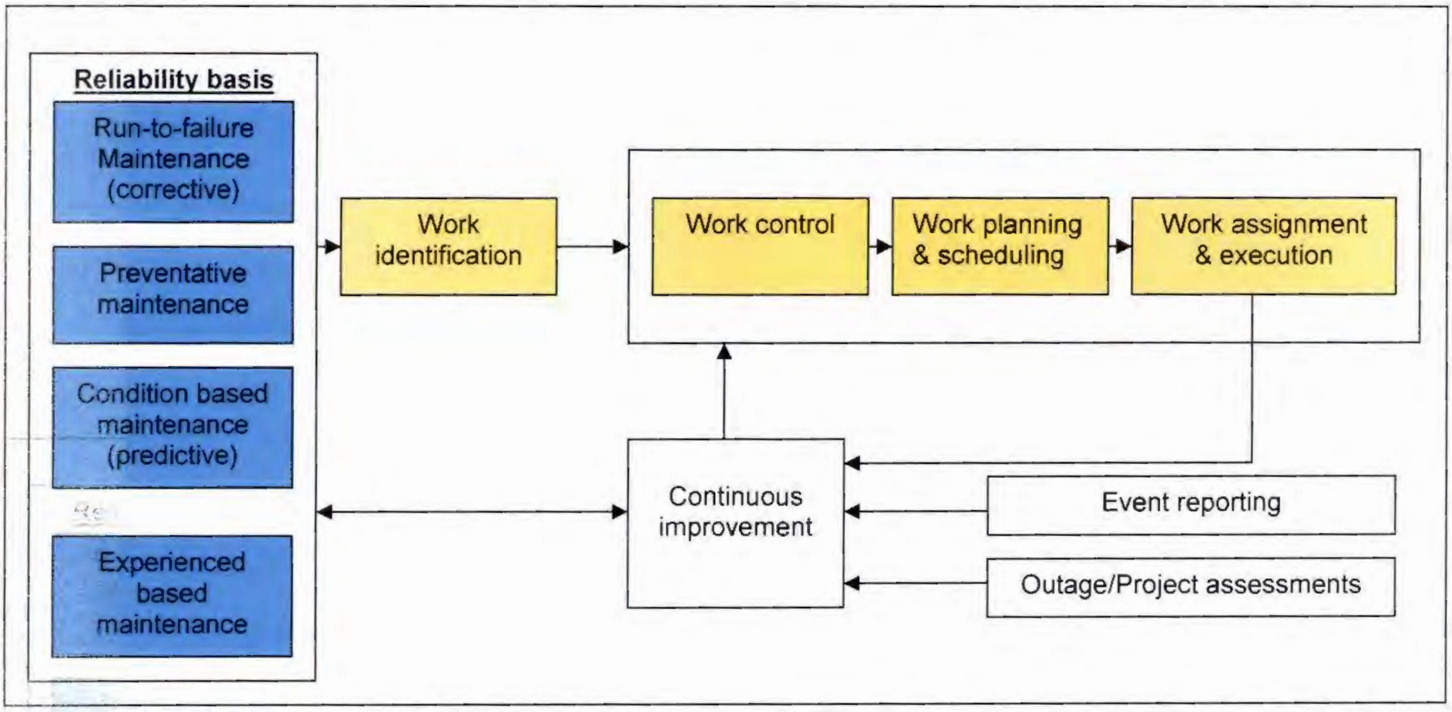
2.6.3.3 Focused improvement (reliability basis optimisation) pillar

Heiser and Render (2006:656) stated that reliability is the probability that a machine part or product will function properly for a specified time under stated conditions. The aim of any maintenance is to improve reliability. Maintenance can be improved by implementing/improving PM and increasing the repair capabilities, or speed and reliability can be improved by improving individual components or/and providing redundancy.

Heiser and Render (2006:657) further noted that design caters for reliability and management maintenance for the operational success of any firm. According to Barber (2009:5), focused improvement is intended to prevent accelerated deterioration of equipment components. The objective of this pillar is to improve the overall equipment effectiveness (OEE). Coetzee (2000:3) terms this pillar a design-out maintenance strategy whose objective is to re-design a particular component to decrease the need for maintenance. The main driver of this pillar is the engineer whose role is critical, especially in the initial design to ensure maintainability is not an issue years later in the operating of the equipment.

Eskom Generation Division document, Core Principles of Reliability Basis Optimisation - GGM1526 (2007:8), defines the reliability basis optimisation as the process of determining and recording the basis of monitoring (proper equipment maintenance for its reliability) and PM activities on equipment.

Figure 2.14: Asset management process (within Eskom Generation)



(Source: Anon., 2009b:6)

During the good (boom) times while the cost of equipment and machinery was still cheap, many companies, including Eskom, improved reliability through redundancy by using similar components in parallel. This option is very expensive because two similar equipments or machines are used to do exactly the same job.

2.6.3.4 Quality pillar

The quality pillar uses the six sigma tools to identify conditions that affect quality, establish a baseline for those conditions and create a process for periodic monitoring of those conditions (Barber, 2009:5).

2.6.3.5 Training and skills development pillar

Rasmussen (in Villemeur, 1991:410) classifies the human functioning or behaviour in three types, namely:

- Skills-based behaviour, which is automatic and the operator 'acts mechanically';
- Rule-based behaviour, which calls on conscious mental activity and consists of coordinated execution of tasks; and
- Knowledge-based behaviour, which an operator acts in less familiar situations and is based on complex conscious mental activity.

All three these behaviours, can only be enhanced by a proper, and properly coordinated, training and skills development program.

TPM is a maintenance work system highly dependent on employees for success. Training of those employees is paramount to achieve business results. Carannante (2008:24) emphasises the importance of training by saying that companies need to train to measure performance, train to develop PMs and train and educate all those involved in TPM for improved business performance.

2.6.3.6 Five-S Pillar (Seiri, Seiton, Seiso, Seiketsu, Shitsuke)

This pillar is the five S's because o Japanese words used which start with a letter '**S**'.

❖ **Sort-out (Seiri)**

According to Venkatesh (2009:8), this means sorting and organising items as critical, important, frequently used items, useless, or items of low need. Items' worth in this pillar should be based on utility and not on cost.

Table 2.2: Priority table

PRIORITY	FREQUENCY OF USE	HOW TO USE
Low	Less than once per year, once per year	Throw away, store away from the workplace
Average	At least 2/6 months, once per month, once per week	Store together but offline
High	Once per day	Locate at the workplace

❖ **Systemise (Seiton)**

This involves placing items on its right and appropriate place. Items should be placed back in the same place after use and heavier items should occupy the bottom position for safety (and ergonomics). For easier identification, items should be colour tagged and have nameplates.

❖ **Sweep or shine the work place (Seiso)**

For safety and better organisation, the workplace should be clean, free of oil, burrs, grease waste and no loose wires.

❖ **Standardise (Seiketsu)**

Standardisation of the workplace and work process is critical to ensure continued improvement. Retailers and franchises are doing this very well and their success of operations is a proof that it works.

❖ **Self-discipline (Shitsuke)**

Self-discipline among employees is an important aspect to ensure that TPM is successfully implemented. Wearing safety apparel, following procedures, punctuality and dedication to the organisation are some of the aspects of self-discipline (Venkatesh, 2009:10).

According to Rich and McCarthy (2008), TPM roles include:

- Developing working practices to stabilise and extend component/tooling life to reduce quality defects (naturally, this also produces cost savings);
- Managing the transferring of routine maintenance activities to production personnel;
- Raising standards of technology care and use to optimise process capability and extend the time between interventions for all personnel;
- Raising standards of maintenance systems including stores, planning, reporting and analysis to support continuous improvement of operations performance; and
- Early management of maintenance projects to support cross project learning, knowledge management and the flawless delivery of new assets.

Under a lean maintenance programme, once technology has been brought under control, the focus shifts from breakdown to quality maintenance. More understanding in principles of lean manufacturing often leads to Maintenance using their own initiative to save or reduce waste. There is also a need to increase awareness across Maintenance to deliver zero breakdowns in order to remove waste and non-value adding activities out of production, and this will result in optimum operational performance at Matimba Power Station.

2.6.3.7 Work management (WM) pillar and its implementation at Matimba

Eskom Generation division did a benchmark study with the Electricity Power Research Institute (EPRI) in 2005 and WM was highlighted as an area which can improve operational performance within the business. Matimba Power Station volunteered to be the pilot site for this WM study, which started in 2007.

The project management phases followed during the process were Concept, where the six-step process (figure 2.11) was accepted, then the Design phase followed, in which the understanding, development and proof of the WM was accepted. The Execution phase followed where changing of structures and support within Matimba Power Station was implemented. The Finalisation phase was introduced immediately after where improvement plans were approved in February 2008 and the Power Station Manager signed the user acceptance. The Eskom policy, directive and procedures governing WM were also developed parallel to the pilot study and were signed by the Generation Division Managing Director in 2007.

Training of the key decision makers and stakeholders started in parallel with the finalisation phase and was completed in February 2008. The two traditional measurements or (KPIs) used in Maintenance were replaced with new KPIs to measure maintenance which are:

- **PM Compliance** (target = 80%) which is a KPI evaluating if the planned (preventative) work was executed as planned for that period (week).
- **Schedule Compliance** (target = 80%) which is a KPI evaluating how well the schedule is adhered to.
- **Emergent work** (target = 20%), which compares emergent work hours (unplanned work) against total hours of planned work.
- **Backlog** (target = 12 weeks) measures all work that is not yet complete.
- **Statutory violations** (target = 0) which count how many statutory work orders were not done during that period (week).
- **Labour utilisation** (target = 60%) measuring how efficient labour is to do preventative work.
- **SAP PM Usage** (target = 80%) which qualifies the accuracy of all KPIs used to measure SAP PM.

Heiser and Render (2006:657) note the importance of work planning and management when they say variability corrupts processes and creates waste and the operations manager must drive out variability. WM's end result and objective is to ensure that work peaks and valleys (variability) are eliminated.

Presently, Matimba Power Station is not performing as it should be. It is not meeting the targets set by Generation division. The only KPIs it is meeting is zero (0) target on Statutory violation after a concerted effort by management to improve maintenance performance. All these KPIs need all employees' effort at Maintenance and Operating department at Matimba to be accomplished, especially artisans and their assistants (utility men). The objective of the study was to evaluate the employee view of WM and identify change management issues that were not handled properly for future full implementation of TPM.

2.7 SUMMARY

Chapter 2 started with an introduction of the topic which included definitions of operations management. A brief overview of Matimba explained the operations from coal input up to electricity production with ash as waste as well as the overview discussion on structures and operational challenges at Matimba.

An operations management discussion followed which included quality, productivity, maintenance within operations, operations performance and employees' involvement in operations, which are also the focus of the empirical study. The maintenance management discussion included definitions related to maintenance, types of maintenance and the current state of maintenance within Matimba.

A new approach to maintenance management, called TPM, was discussed starting with definitions related to TPM. To help understand TPM, background information was discussed, together with the five pillars of TPM. Lastly, the WM pillar of TPM was re-visited so that the objectives of the study can be met.

CHAPTER 3

EMPIRICAL STUDY

3.1 INTRODUCTION

To achieve the primary objective of this study, chapter 2 dealt with quality, productivity, integration, employee involvement, maintenance (including types, tools and methods thereof) and TPM (Total Productive Maintenance) together with its five pillars to explain factors critical for successful and effective operations management at Matimba Power Station. The deficiencies and challenges within Operations are investigated in order to improve operational performance at Matimba Power Station.

Gaither and Frazier (2001:661) list people (employees) more than any other factor, as critical for operations success. They affect morale, costs, productivity, quality and customer satisfaction. The employees need to be empowered to take a more active role in operations decision-making thus the inclusion of employee involvement in the literature study. The implementation of WM posed challenges with regard to employee involvement and communication, and the empirical study measures this to achieve the study objectives.

The employees are divided into two groups (artisan and operators) based on their reporting structure at Matimba. The artisans (which include the utility men, technicians and planners) are all in the Maintenance department and the operators (including unit controllers) are in the Operating department. The objective was to measure the positions and views of different groups of employees with regard to implementation of WM at the Power Station which is one of the identified pillars of TPM. The task thereafter was to identify the thinking discrepancies that exist among the different groups in Matimba and once identified, to determine the statistical significance of these differences (Bisschoff & Fullerton, 2007:20).

A quantitative survey of artisans (from the Maintenance department) and operators (from the Operating department) was taken to measure the employees' perception of TPM and implementation of WM at Matimba Power Station. During the empirical study, the respondents were asked to indicate their level of agreement or disagreement with the TPM pillar of WM implemented at Matimba Power Station.

The study also determined the position and views of Matimba employees in terms of the implementation of WM, which is one of the pillars of TPM to achieve the secondary objective. Through this research, the views of Matimba employees in terms of the implementation of TPM were analysed to improve the thinking towards implementation in section 3.3.

3.2 SAMPLE SELECTION

The sample for the empirical study of 19 Operating employees and 24 Maintenance employees (sample total of 43) was randomly selected from 180 operating employees and 209 maintenance employees, which make a population of 389. From the three technical departments at Matimba, the only respondents in the research were from Operating and Maintenance, because only these two departments' employees will effect successful implementation of work management. All the respondents were randomly selected from the employee list of the two departments.

3.3 MEASURING INSTRUMENT

The format of the measuring instrument design is similar to the one developed by Bisschoff and Fullerton's (2007) research on ethical profiling of students from different departments. Using this format, the respondents were asked to indicate their opinions with regard to WM.

In the questionnaire, the respondents were asked on their views on the implementation of WM and their perception about the possible full implementation of TPM. They were also asked if they would participate in any alternative future endeavour to improve operations at the workplace. The measurement scale was a balanced 6-point itemised rating scale with a median of 3.5. The data were compiled and distributed to Operating staff (operators) and Maintenance staff (artisans) who responded to the questionnaire.

3.4 DESIGN OF THE RESEARCH AND QUESTIONAIRE

A total of 43 questionnaires were distributed to respondents. A grand mean calculated was used as a reference for developing a single aggregate measure by which the views of 43 respondents could be compared.

The 6-point scale was deliberately chosen so that no-one should be "sitting on the fence": they should either agree or disagree and had to indicate the scale of their agreement or disagreement. On the 6-point scale any question exceeding the mean of 3.5 (that is, a median in a 6-point scale) will be on the agreement side of the scale while any question lower than the mean of 3.5 will be on the disagreement side.

The questionnaire was mainly used to get the views of two technical departments' staff members, namely Operating and Maintenance. This is more appropriate because the implementation of WM involve only employees from the two department mentioned. The two departments combined also have a staff compliment of 68% of the Matimba total thus influencing the majoring view. Engineering department is only affected by the focused improvement (reliability basis optimisation) pillar of TPM which is still to be implemented in future at Matimba.

Although the questionnaire was the same for both departments, the answering of it was totally different in the sense that the insinuation was for operator or artisan to do each other's jobs, and that received different responses based on the view of each group towards each other.

The questions in the questionnaire were divided into different groups. Section A of the questionnaire contained the demographic information for respondents' profiling. For example, the age question was important because of the reluctance of the older generation employees to subscribe to new ways of doing things. Section B was the core of the empirical study and consisted of 20 questions.

Questions 1 to 3 highlighted <u>communication</u> issues in the implementation of WM. Questions 4 to 6 measured the <u>performance</u> and <u>effectiveness</u> of employees' view on the new implemented system of WM. The <u>team integration</u> view of the employees was measured in Question 7. Sharing of responsibilities of the different departments' view was measured in Questions 8 to 12, and Question 13 measured training. Work practices within the Power Station were measured in Questions 14 to 15. Experience and expertise on equipment and exposure to WM were measured in Questions 16 to 18. Interference views on WM were expressed in Question 18 and views on change were expressed with Question 19. Lastly, the views of continuing on full implementation of TPM were measured in Question 20.

3.5 STATISTICAL ANALYSIS AND RESULTS

Starting at Section A, which deals with demographics, the racial profiling of respondents was not necessary in this study. The age of the respondents was deemed necessary as it has been noted in general perceptions and previous human behaviour studies that younger employees are more adaptable to change than older employees. The average age of respondents was 37 years for the Operating Department and 34 years for the Maintenance Department thus meaning that the average age of Operating is higher than that of Maintenance. Results show Maintenance employees as more agreeable (mean = 5.12) to change than Operating employees (mean = 5.05), although Operating supports full implementation of TPM at a mean of 4.84 versus 4.33, and with minimal standard deviations from these means. Matimba employees totally agree that things need to change for effective operation of the power station.

The average years' work experience of the departments are 12 years for Operating and 11 years for Maintenance, meaning that the Operating department has more work experience on the Matimba plant than Maintenance.

3.5.1 Mean values

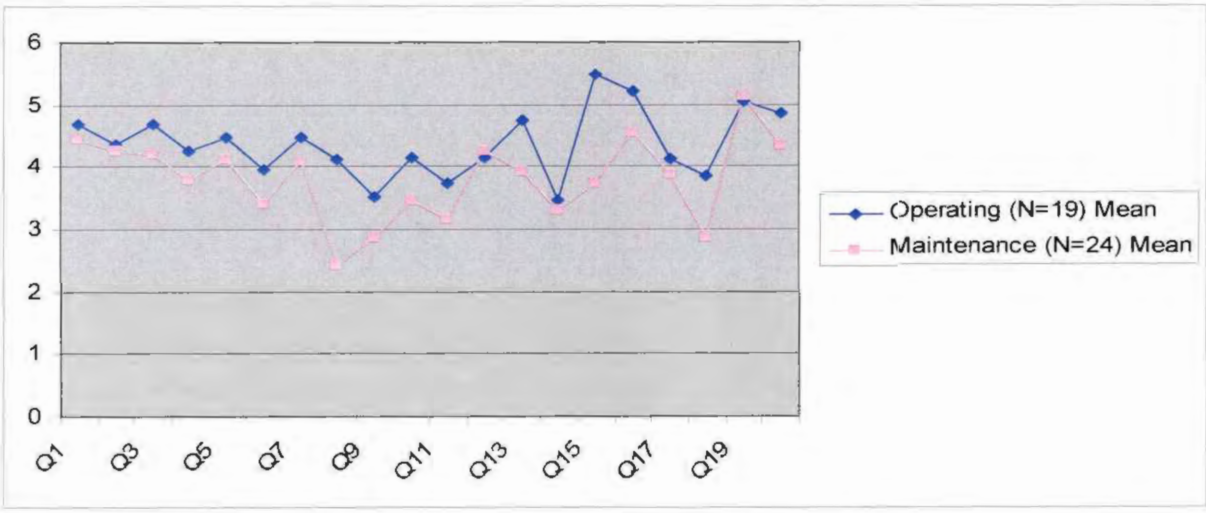
The grand mean of the Operating department was 4.36 and the grand mean of the Maintenance department was 3.81. This result implies that the Matimba departments (Operating and Maintenance) are in agreement in general terms of implementation of WM. The two grand means compared (as in Table 3.1 and figure 3.1) highlight the fact that the Operating department is more agreeable to the views posed by the questionnaire than Maintenance. This discrepancy might be due to the fact that the

Maintenance staff thinks that WM management is going to affect them more severely than other departments and that they should tread carefully with any management initiatives.

Table 3.1: Mean values of the employees' views on WM

CRITERION	OPERATING	MAINTENANCE	SAMPLE
	(n=19)	(n=24)	(N=43)
Q1	4.68	4.45	4.56
Q2	4.36	4.25	4.30
Q3	4.68	4.20	4.44
Q4	4.26	3.79	4.02
Q5	4.47	4.12	4.29
Q6	3.94	3.41	3.67
Q7	4.47	4.08	4.27
Q8	4.1	2.41	3.25
Q9	3.52	2.87	3.19
Q10	4.15	3.45	3.8
Q11	3.73	3.16	3.44
Q12	4.15	4.25	4.20
Q13	4.73	3.91	4.32
Q14	3.47	3.29	3.38
Q15	5.47	3.75	4.61
Q16	5.21	4.54	4.87
Q17	4.1	3.87	3.98
Q18	3.84	2.87	3.35
Q19	5.05	5.12	5.08
Q20	4.84	4.33	4.58
Grand Mean	**4.36**	**3.81**	**4.08**

Figure 3.1: Views of Operating and Maintenance employees (means)



3.5.2 Standard deviations results

The standard deviations calculated (Table 3.2 and Figure 3.2) are between the values of 0.84 and 1.93 for Operating and between 1.32 and 1.95 for Maintenance. No outliners (extreme values) were identified in the readings. The resultant standard deviations recorded were non-significant and thus there was no need to analyse them.

Figure 3.2: Views of Operating and Maintenance employees (standard deviations)

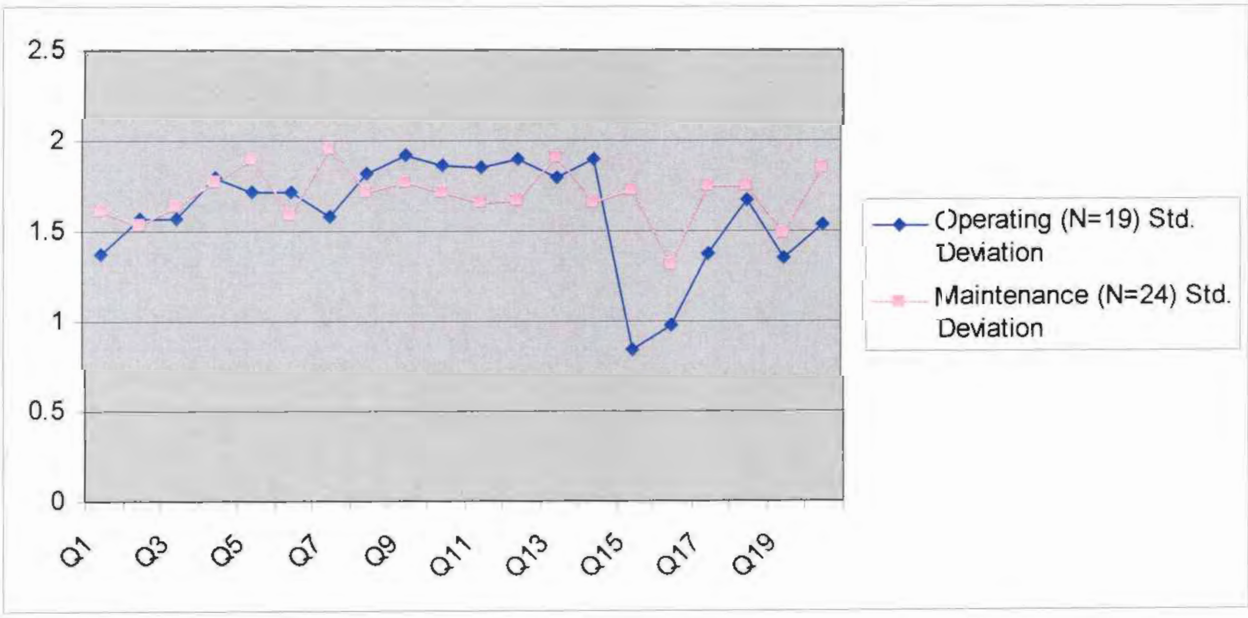


Table 3.2 Standard deviation values of the employees' views on WM

CRITERION	OPERATING (n=19)	MAINTENANCE (n=24)
Q1	1.376494403	1.614584794
Q2	1.570934835	1.539339215
Q3	1.565340984	1.64129235
Q4	1.790161547	1.768791449
Q5	1.71167303	1.895360468
Q6	1.71508614	1.585715218
Q7	1.576508838	1.954185401
Q8	1.822535988	1.717345441
Q9	1.925513526	1.776966149
Q10	1.863782233	1.718927033
Q11	1.851188965	1.659404468
Q12	1.893355572	1.674618711
Q13	1.790161547	1.909169331
Q14	1.896441728	1.654484464
Q15	0.841191024	1.725763851
Q16	0.976328005	1.318073913
Q17	1.370106924	1.752327645
Q18	1.675415633	1.752327645
Q19	1.35292622	1.483606065
Q20	1.537066394	1.857222486

3.5.3 Test of significance

According to Ellis and Steyn (2003:52), statistical significance tests have a tendency of yielding small p-values especially as the sizes of data sets increase, indicating significance which may lead to misinterpretation as statistical significance does not imply that the result is important in practice.

The measure that is more appropriate will be the practical significance which can be understood as a large enough difference to have an effect in practice. Cohen (1988) gives the following guidelines for the interpretation of the effect size:

- For small effect: effect size = 0.2;
- For medium effect: effect size = 0.5; and
- For large effect: effect size = 0.8.

Table 3.3: Matimba employees' views on WM (test of significance)

	TYPE	N	MEAN	STD. DEVIATION	STD. ERROR MEAN	EFFECT SIZE
Q1	Operating	19	4.68	1.376	.316	
	Maintenance	24	4.46	1.615	.330	0.14
Q2	Operating	19	4.37	1.571	.360	
	Maintenance	24	4.25	1.539	.314	0.08
Q3	Operating	19	4.68	1.565	.359	
	Maintenance	24	4.21	1.641	.335	0.29
Q4	Operating	19	4.26	1.790	.411	
	Maintenance	24	3.79	1.769	.361	0.26
Q5	Operating	19	4.47	1.712	.393	
	Maintenance	24	4.13	1.895	.387	0.18
Q6	Operating	19	3.95	1.715	.393	
	Maintenance	24	3.42	1.586	.324	0.31
Q7	Operating	19	4.47	1.577	.362	
	Maintenance	24	4.08	1.954	.399	0.20
Q8	Operating	19	4.11	1.823	.418	
	Maintenance	24	2.42	1.717	.351	0.93
Q9	Operating	19	3.53	1.926	.442	
	Maintenance	24	2.88	1.777	.363	0.34
Q10	Operating	19	4.16	1.864	.428	
	Maintenance	24	3.46	1.719	.351	0.38
Q11	Operating	19	3.74	1.851	.425	
	Maintenance	24	3.17	1.659	.339	0.31

Table 3.3: Matimba employees' views on WM (Test of significance) (continued)

Q12	Operating	19	4.16	1.893	.434	
	Maintenance	24	4.25	1.675	.342	**0.05**
Q13	Operating	19	4.74	1.790	.411	
	Maintenance	24	3.92	1.909	.390	**0.43**
Q14	Operating	19	3.47	1.896	.435	
	Maintenance	24	3.29	1.654	.338	**0.10**
Q15	Operating	19	5.47	.841	.193	
	Maintenance	24	3.75	1.726	.352	**1.00**
Q16	Operating	19	5.21	.976	.224	
	Maintenance	24	4.54	1.318	.269	**0.51**
Q17	Operating	19	4.11	1.370	.314	
	Maintenance	24	3.88	1.752	.358	**0.13**
Q18	Operating	19	3.84	1.675	.384	
	Maintenance	24	2.88	1.752	.358	**0.55**
Q19	Operating	19	5.05	1.353	.310	
	Maintenance	24	5.13	1.484	.303	**0.05**
Q20	Operating	19	4.84	1.537	.353	
	Maintenance	24	4.33	1.857	.379	**0.27**

From Table 3.3 on the calculation of effect size, using the Cohen (1988) guideline as reference, questions 8 and 15 (at effect sizes of 0.93 and 1.00 respectively) came out as having practical significance.

3.6. QUESTIONAIRE ANALYSIS AND RESULTS

A total of 50 questionnaires were distributed. Seven respondents did not submit their responses.

3.6.1 Communication and employee involvement in WM (Question 1-3)

Both Operating and Maintenance agree with question 1 that WM implementation could have been successful if management communicated with and involved employees from the very beginning. Although initial communication with employees took place, active engagement with employees was not done.

3.6.2 Performance and effectiveness of WM (Question 4-6)

Consensus from both Operating and Maintenance employees is that WM is good for Matimba although Maintenance is almost on the borderline at a mean of 3.79.

3.6.3 Team integration (Question 7)

In Question 7, the idea of WM improving the team spirit between Operating and Maintenance employees is asked with both parties agreeing with a mean of 4.27.

3.6.4 Sharing of responsibilities (Question 8-12)

Questions 8 and 9 had different views on the question of whether improvements will be realised if operators do artisan work. Operating personnel agreed on these questions while Maintenance totally disagreed at means of 4.1 versus 2.4, and 3.52 versus 2.87 respectively. Question 10 also showed that the Operating department is willing to assist Maintenance to do routine work at a mean of 4.15, but the Maintenance department disagreed with the question at a mean of 3.45. Maintenance also disagreed with question 11 of taking over the responsibilities of plant operating and isolations from their Operating colleagues at a mean of 3.16 versus 3.73, although in Question 12, they agreed only to help and not to be permanent maintenance staff (mean of 4.25).

3.6.5 Training (Question 13)

Both the departments' employees strongly agreed that they are willing to be trained for either Operating or Maintenance work, at a mean of 4.2.

3.6.6 Work practices within Matimba (Question 14-15)

The two departments also disagreed with the notion that maintenance is done unnecessarily on the Plant at an average mean of 3.38. This question was brought on by the fact that some PM is scheduled unnecessarily due to the periodic nature of WM.

This is an indication that the WM schedule should be left as it is. Both the departments agreed that operators are doing what they are supposed to do in terms of first line maintenance (plant inspections) which is the responsibility of Operations (mean of 4.61 in question 15). This question was brought on by perceptions that Operating is not doing inspections on the Plant in order to address Plant problems before they become Plant failures.

3.6.7 Experience and expertise on equipment and plant (Question 16-17)

The responses of both departments to Questions 16 and 17, on the experience and expertise on equipment and exposure to WM are in strong agreement with an average means of 4.87 (Operating) and 3.98 (Maintenance).

3.6.8 Interference of WM on existing processes (Question 18)

Question 18 sees the two departments having a different view on the question of whether WM is a problem to their respective jobs with Operating agreeing at a mean of 3.84 and Maintenance disagreeing at a mean of 2.87. Operating's view that WM is a "hassle" to their job may be due to the fact that Operating does not understand WM, and currently WM at Matimba is driven by Maintenance.

3.6.9 Support for change (Question 19)

The strong positive feedback received from question 19 on the need for change to ensure success at Matimba is highlighted by a mean of 5.08. This highlights the fact that the employees will strongly support change that will bring success to Matimba Power Station.

3.6.10 Implementation of TPM (Question 20)

There is also strong support that management at Matimba should fully implement TPM to ensure success at the Power Station as indicated by the results of question 20 (mean of 4.58).

3.7 SUMMARY

Chapter 3 provided the results of the empirical study. The chapter analysed the Operating and Maintenance variables, and tested if significant practical differences do exist between them. The next chapter is the final chapter of the study. It draws the conclusion and offers some recommendations befitting the empirical research.

CHAPTER 4

CONCLUSION AND RECOMMENDATIONS

4.1 INTRODUCTION

Effective operations management in Eskom power stations (including Matimba) cannot happen without proper maintenance management. Maintenance is the most important part in the electricity generation industry because of plant high capital costs and specialty of tasks involved in maintenance. This high capital cost is also due to the fact that there are less than ten suppliers of power station plant items like boilers, generators and turbines that Eskom uses worldwide. For nuclear power plants, there are less than five suppliers. Most of the Eskom power plants are dependent on these scarce suppliers for specialist maintenance needs.

Proper maintenance management will help any organisation like Matimba Power Station in planning, scheduling, and managing work requirements and maintenance tasks-jobs that are critical to keep the operations going, such as daily, recurring, preventative, and predictive maintenance work thus resulting in improved operational performance.

The literature study acknowledge worldwide best practices of operational and maintenance management experience, mainly based on Japanese experience. The partial implementation of total productive maintenance (TPM), particularly the work management process is facing challenges, and employee input for its success is critical for Matimba Power Station. Employee involvement in Operations is also highlighted as critical for success. The full implementation of TPM cannot happen if work management (WM) is not successful at Matimba, and this will be measured through operational improvement.

The empirical study conducted with Matimba employees (mainly from the Maintenance and Operating departments) as participants identified the weakness during the implementation of WM. It also highlighted the non-involvement and lack of communication during the initial stages of WM.

4.2 CONCLUSION

The maintenance and effective management within the Matimba Power Station plays a pivotal role in ensuring availability of the plant generating electricity because of the high capital investment the Power Station has made in procuring the assets. Although Matimba Power Station is performing excellently in its operations and maintenance, an effort is made to ensure the continuous improvement in Matimba operations process.

The bottlenecks and problems within Matimba operations processes were identified and the solutions were provided in the literature study, and are spelt out for Matimba management to implement for effective operations.

The empirical study survey in the form of a questionnaire was used to understand the impact of maintenance work management (a SAP PM system) to effective operations at Matimba Power Station and also an understanding of TPM for possible implementation at Matimba Power Station. The evaluation of the preparedness of the Matimba Power Station to launch a TPM in order to enhance integration with other departments to lead to continued operations success at Eskom Power Stations was done and further than that, a culture and process of continuous improvement was made during the study, and the efforts of management will be to instil a culture change in Matimba to lead to long-term operational excellence.

The results of the empirical study indicate not only the problems in the implementation of WM but also present the opportunities for further implementation of TPM at Matimba Power Station.

4.3 ACHIEVEMENT OF THE OBJECTIVES

The objectives of the research were met as illustrated in the literature study by investigating maintenance integration with other departments for operational success at Matimba Power Station. The objectives of this study have been achieved by doing research in the following instances:

- Chapter Two: A literature study was done and through operations management, maintenance management and TPM, suggestions are raised on how Matimba Power Station operations can be more effective.
- Chapter Three: An empirical study identified problems of WM and involvement of employees in the implementation of important systems like WM, and opportunities for further implementation of TPM in Matimba were identified.

4.4 RECOMMENDATIONS

4.4.1 Structures and responsibilities

The Eskom Board and Government need to reconsider the long-term coal supply strategy for Eskom power stations. The present strategy of exporting good coal and letting low quality coal to be used for domestic purposes is creating operation problems for most power stations due to boiler tube leaks as indicated in section 2.3.3, causing unnecessary plant outages.

The main focus of success measurements is on the short-term achievements involving Maintenance and Operating Departments. Measurements of Engineering department's goals and responsibilities especially in terms of long-term Plant health is critical for long-term success and it is something that Matimba needs to give attention to.

4.4.2 Challenges facing Matimba

The Supply Chain Management issues identified in the literature study need to be addressed by Matimba management. Stock levels need to go down to the minimum thus saving storage and maintenance of inventory costs. The in-efficiencies within Matimba operations are presently being hidden by high inventory level, and will be exposed. Investment in new technology like the scanners and Radio Frequency Identification (RFID) will ensure that the costs of management and upkeep of stores go down and productivity improves.

4.4.3 Quality management

Matimba management should implement a comprehensive quality management system that integrates all departments. Maintenance initiative of re-work measurement should be supported and be included in the quality management system. The absence of quality management within the structures of Matimba Power Station is the item management should look at. One department within the structure should be accountable to ensure that quality processes are adhered to.

4.4.4 Integration between departments

Departments within Matimba Power Station should be discouraged from working in silos and closer relationship between departments at Matimba will ensure operational success. Close cooperation and alignment in objectives between department managers will lead to employee relations between departments improving thus leading to successful implementation of Total Productive Maintenance. The Power Station Manager should ensure that intra-company politics within his team of managers should not interfere with their main, common work of achieving operational excellence.

4.4.5 Employee involvement in change initiatives

The information flow and communication between managers and employees will lead to better working relations between management and employees. Employees need to know which direction Matimba Power Station is going so that they can be "active participants in the journey".

The trust between management and employees will be enhanced if management values employees' inputs in change initiatives like work management. This empowering initiative will ensure that implementation of processes and systems face little resistance from employees.

4.4.6 State of Maintenance at Matimba

The Engineering Department with Matimba Power Station needs to assist Maintenance to sort out Ash and Coal Plant problems to ensure long-term Plant health has maintenance as their key responsibility.

The boiler tube leaks problems will be addressed if Government and the Eskom Board change their coal procurement strategy.

The present age profile (average 34 and 37 years) and work experience of 11 years (average) is an indication of the dire need of trained artisans and operators. Matimba Power Station needs training of artisans and operators to be intensified for future skills challenges facing Matimba and other Eskom power stations.

4.4.7 Total Productive Maintenance (TPM)

The excellent operational performance of Japanese companies like Toyota is enough testimony that TPM is critical for success of operations like Matimba. The successful implementation of TPM will ensure that costs at all levels of operations are minimised.
The TPM should be implemented without a delay, in consultation and involvement with employees, as the empirical studies indicated. Employee involvement is critical because TPM involves also a culture change within any organisation. This should be done in phases to ensure that daily operations are not affected.

4.5 SUMMARY

The operational success of Matimba Power Station is dependent on management not being relaxed or complacent. Basking in past achievement or glories is what have killed many organisations and being competitive also involves looking at what your competitors are doing and analyse the best practices globally.

The literature study provided the best practices in terms of operations management and maintenance management. The empirical study provided the review of Matimba's internal engagement with its employees and uses this as a base to learn and move forward to ensure success of its operations by implementing the recommendations of this study.

REFERENCES

ACTS *see* SOUTH AFRICA.

ADENDORFF, S.A., BOTES, P.S. DE WIT, P.W.C., VAN LOGGERENBERG, B.J., STEENKAMP, R.J. 1999. Production and operations management, 2nd ed. Boston, Mass.: Oxford University Press.

ANON. 2007a. Eskom plant asset management directive. GGD 1447 Rev 0, July 2007. Johannesburg: Unpublished.

ANON. 2007b. Routine work management manual (GGM 1490). Eskom Generation document. Johannesburg:Unpublished.

ANON. 2007c. Eskom routine work management manual. GGM 1490 Rev 0, September 2007. Johannesburg:Unpublished.

ANON. 2009a. The history and impact of Total Productive Maintenance. [Web]: http://www.reliabilityweb.com Date of access: 22 February 2009.

ANON. 2009b. Eskom leading metrics manual GGM1539. Johannesburg: Unpublished.

ARMY, D.A. 2008. Measure behaviour, measure success. Plant maintenance resource centre. [Web]: http://www.plant-maintenance.com/articles/measure_behaviour.shtml Date of access: 10 October 2009.

BARBER, J. 2009. The TPM experience. [Web:] http://www.totalproductivemaintenanceconference.com Date of access: 23 May 2009.

BISSCHOFF, C.A. & FULLERTON, S. 2007. The ethical views of university students at the Potchefstroom Campus of NWU. Proceedings of the 2nd International Business Conference. Port Elizabeth.

CARANNANTE, T. 2008. TPM implementation: critical success factor. *Management and maintenance journal*, 21(4):22-27.

CHASE, R.B., AQUILANO, N.J. & JACOBS, F.R. 2006. Production and operations management for competitive advantage. 11th ed. Boston, Mass.: Irwin/McGraw-Hill.

COETZEE, J.L. 2000. Maintenance strategy setting: a dangerous affair. South African paper presented at the IFRIM World Trends in Maintenance Conference, Pretoria, South Africa.

COHEN, J. 1988. Statistical power analysis for behavioural sciences. 2nd ed. Hillsdale, N.J.: Erlbaum.

CORDER, A.S. 1976. Maintenance management techniques. New York, N.Y.: McGraw-Hill.

ELLIS, S.M. & STEYN, H.S. 2003. Practical significance (effect sizes) versus or in conjunction with statistical significance (p-values). *Management dynamics*, 12(4):51-53.

ERA ***see*** SOUTH AFRICA.

FERREIRA, I.W. 2006. Project portfolio management's contribution to effective strategy execution. Potchefstroom: NWU. (Dissertation – MBA).

GAITHER, N. & FRAZIER, G. 2001. Operations management. 9th ed. Nashville, TN.: South Western.

GAO, H. 2007. PIM scheduling with multi-skilled workforce constraints: models, algorithms and applications. University of Mississippi (Dissertation – PhD.).

HEISER, J. & RENDER, B. 2006. Operations management. 8th ed. New Jersey, N.J.: Prentice Hall.

HOLMAN, L. & BUZEK, G. 2009. Just how big is the out of stock problem in retail. [Web]: www.scdigest.com Date of access: 20th January 2009.

KODALI, R., ANAND, G. & MISHRA, R. 2008. The evolution of maintenance. *Asset management and maintenance journal*, 23(3):123-147.

KRUGER, D., RAMDASS, K. & DE WIT, P. 2005. Operations management. South Africa: Oxford University Press.

LEVERY, M. 2008. Motivating maintenance craftsmen, did we know what we are doing? [Web]: www.mclconsultancy.co.uk Date of access: 21 January 2009.

LIKER, J. & MEIER, D. 2006. The "Toyota Way" fieldbook. New York, N.Y.: McGraw-Hill

McCALL, J. 1965. Maintenance policies for stochastically failing equipment: a survey. *Management science*, 11(5):493-524.

MOUBRAY, J. 2001. Maintenance management, a new paradigm. New York, N.Y.: Industrial.

MUHLEMAN, A., OAKLAND, J. & LOCKYER, K. 1993. Production and operations management. 6th.ed. London: Pitman.

PATTON, J.D. 1988. Maintainability and maintenance management. Instrument Society of America. Triangle Park, N.C.: Services.

RICH, N. & McCARTHY, D. 2008. What is lean maintenance? [Web:] http://dakconsulting.co.uk/contents_articles.html Date of access: 8 June 2009.

ROLLINS, T. 2003. Human capital index. [Web]: www.watsonwyatt.com Date of access: 15 June 2009.

SINGER, T. 2002. Breaking down boundaries: Time to integrate plant engineering into the supply chain. *Plant engineering* [Web]: http://www.plantengineering. com/article/185604-Breaking_down_boundaries_Time_to_integrate_plant_ engineering_into_the_supply_chain.php Date of access: 10 October 2009.

SLACK, N., CHAMBERS, S., HARLAND, C., HARRISON, A. & JOHNSTON, R. 1998. Operations management. 2th.ed. London: Pitman.

SOUTH AFRICA. 1994. Occupational Health and Safety Act 85 of 1994 (General Machinery Regulation 2.1 (GMR 2.1) Pretoria: Government Printer.

SOUTH AFRICA. 2006. Electricity Regulation Act (No.4 of 2006). Pretoria: Government Printer.

STAGNARO, S. I. 2001. Understanding the ABC of plant maintenance. *Plant engineering,* 2:105-106, February. [Web]: http://www.proquest.com/ Date of access: 27 January 2009.

VENKATESH, J. 2009. What is TPM? [Web]: http://www.plant-maintenance.com/articles/tpm_intro.shtml Date of access: 23 May 2009.

VILLEMEUR, A. 1991. Reliability, availability, maintainability and safety assessment. Vol.2. New York, N.Y.: Wiley.

VINEYARD, M.L. & MEREDITH, J.R. 1992. Effect of maintenance policies on FMS failures. *International journal of production research*, 30:2647-2657.

WILLMOTT, P. 2008. TPM – the 'Pinch-Point solution' for lean manufacturing. *Asset management and maintenance journal,* 21(4):22-27.

Appendix A

Evaluation for TPM implementation (Operators/Artisans)

The objective of the questionnaire is to gauge the employee engagement and participation during the implementation of Work Management which is one of the pillars of TPM. TPM is a methodology used by successful maintenance organisations to eliminate waste and improve productivity. The idea is to test if Matimba can optimally use its resources and for Operating department to do routine work and thus releasing Maintenance department to do more intensive, intrusive and specialist maintenance work. Please answer the following questions/ statement by crossing (X) in the space provided.

Procedure for completing the questionnaire

1. There is no right or wrong answer. Only tick once if you agree or disagree with the statement made.

Example 1

1. Do you agree with the present maintenance philosophy?

1	2	3	4	5	6
				X	
Disagree					Agree

A. Background Information

This section of the questionnaire refers to background or biographical information. Although we are aware of the sensitivity of the questions in this section, the information will allow us to compare groups of respondents. Once again, we assure you that your response will remain anonymous. Your co-operation is appreciated.

1. Gender

Male	
Female	

2. Age (in complete years)

3. Ethnicity

Black	
White	
Coloured	
Indian or Asian	

4. Your highest educational qualification

Other	
Abet 3	
Grade 11 (std 9)/Trade	
Grade 12 (Matric, std 10) / Trade	
Post-Matric Diploma or certificate	
Baccalaureate Degree	
Post- Graduate Degree	

5. Department I am working for is

Operating	
Maintenance	

6. I am presently occupying a position of

Operator	
Artisan	
Utility man	
Unit Controller	
Technician	
Supervisor	
Other	

7. I have been in this position for (in complete years)

8. I have been working for Eskom for (in complete years)

B. Questionnaire/Statements

1. Implementation of Work Management (WM) would have made the difference, considering its (WM) performance now, if management initially involved employees.

1	2	3	4	5	6
Disagree					Agree

2. Management communicated with employees during the implementation of Work Management.

1	2	3	4	5	6
Disagree					Agree

3. The consultation with employees would have improved the buy-in from employees on the new Work Management.

1	2	3	4	5	6
Disagree					Agree

4. Success of Matimba is dependent on Work Management.

1	2	3	4	5	6
Disagree					Agree

5. Work Management will improve performance (add value) at Matimba.

1	2	3	4	5	6
Disagree					Agree

6. Our new Work Management system is effective.

1	2	3	4	5	6
Disagree					Agree

7. Work Management will improve working relations (team spirit) between Maintenance and Operating departments.

1	2	3	4	5	6
Disagree					Agree

8. Improvements will be realised if Operators do artisans' work.

1	2	3	4	5	6
Disagree					Agree

9. Operators will be able to do routine maintenance work artisans presently do.

1	2	3	4	5	6
Disagree					Agree

10. Operating is prepared to help maintenance to do routine work.

1	2	3	4	5	6
Disagree					Agree

11. Artisans will be able to do Operating and isolations in the plant.

1	2	3	4	5	6
Disagree					Agree

12. You will help to do routine maintenance / operating and isolations.

1	2	3	4	5	6
Disagree					Agree

13. You are keen to be trained to do Operators/Artisans work?

1	2	3	4	5	6
Disagree					Agree

14. Maintenance work is being done unnecessarily (i.e. interference with good running plant) on some equipment.

1	2	3	4	5	6
Disagree					Agree

15. Operators are doing what they are supposed to do (i.e. to improve running of the plant.

1	2	3	4	5	6
Disagree					Agree

16. You have the expertise on the plant/equipment you are responsible for.

1	2	3	4	5	6
Disagree					Agree

17. You fully understand Work Management and its objectives.

1	2	3	4	5	6
Disagree					Agree

18. You see the Work Management as a hassle to your job.

1	2	3	4	5	6
Disagree					Agree

19. In order to ensure success of Matimba, things need to change.

1	2	3	4	5	6
Disagree					Agree

20. Management should fully implement TPM to ensure success at Matimba.

1	2	3	4	5	6
Disagree					Agree

THANK YOU FOR YOUR TIME