MAINTENANCE MANAGEMENT AND IMPACT ON ORGANISATIONAL PERFORMANCE, A POWER UTILITY PERSPECTIVE

B. Javani[1*], N. Jafta[2] and M. Dewa[3]
[1*]Department of Business Studies
Management College of Southern Africa, South Africa
javanib@yahoo.com

[2]Department of Business Studies
Management College of Southern Africa, South Africa
jaftanb@gmail.com

[3]Department of Industrial Engineering
Durban University of Technology, South Africa
mendond@dut.ac.za

ABSTRACT

Increased plant availability, equipment reliability and safety and health of the personnel have become the significant aspect of the maintenance function within power generation. This paper positions maintenance functions and their impact on organizational performance from a power utility perspective. Research data was collected based on semi-structured interviews on thirteen maintenance engineering management personnel. The findings indicate that the challenges facing maintenance teams in executing maintenance activities include, ageing plant, staff shortage, lack of skills and knowledge and low employee morale. The paper recommended adoption of world class maintenance framework, for maintenance to achieve greater operational performance.

Keywords: Maintenance management, Organisational performance, Plant availability

* Corresponding Author

1 CONTEXT

1.1 Background

A combination of increased electricity demand coupled with deficit in power supply has resulted in the power utility organisation to focus more on plant maintenance. Power plants are deteriorating thus power stations are not operating at the required capacity resulting in almost half of the current power outages Baker and Phillips [1] Motepe et al., [2]. This implies that more maintenance work and financial assistance is required to keep them online. Additionally, is the need to increase power plant maintenance to minimize the risk of unreliable and unsatisfactory plant performance Velayutham and Ismail [3]. As such, the power utility must reduce downtime and increase plant availability to ensure sustainable economic growth. This is aligned to the global move concerning asset management aimed at improving power plant equipment reliability, availability, and maintainability Motepe et al., [2] Global Forum on Maintenance and Asset Management [4].

Velayutham and Ismail [3] stated that internal effectiveness of an organisation is influenced by the maintenance role and impacting on areas such as production, quality, production cost, working environment, work in progress and tied up capital. Foon and Terziovski [5] have also discussed the importance of the maintenance function in keeping and improving asset availability, performance efficiency and product quality. Therefore, the maintenance function plays a critical role on the ability of the organization to minimise loss, financial or otherwise Global Forum on Maintenance and Asset Management [4]. The foregoing indicates that, if maintenance is effectively executed an organisation will compete based on costs, quality, and service delivery performance resulting in enhanced productivity and profitability Velayutham and Ismail [3]. This implies that improvement in maintenance functions can have positive impact on the achievement of optimised production output.

1.2 Problem Statement

Velayutham and Ismail [3] states that, to sustain power plant operations such as, plant efficiency and availability, safety of employees, environmental safety, and high-quality production, it is generally depends on how organizations effectively co-ordinate and manage the maintenance function. Therefore, it is required to establish maintenance related issues, before developing and implementing an improved system Parida and Kumar [6] Maletič et al., [7]. Unplanned capability loss factor (UCLF) measures the unplanned pant breakdowns Motepe et al., [2]. The UCLF was around 80% in 2019, compared to 20% in 2010 against a best practise of 10% Motepe et al., [2]. The foregoing indicates that generation performance due to unreliable plant and poor maintenance performance is deteriorating and requires attention to improve plant performance. The aim of this research is to investigate challenges facing maintenance management and the resulting impact on the power utility's performance. Lastly the study provides recommendations on how to improve maintenance management.

2 LITERATURE REVIEW

2.1 Maintenance and the Maintenance Function

Maintenance has been defined as combination of all technical and administrative actions, including supervisory actions, intended to retain an item in, or restore it to, a state in which it can perform a required function ISO 14244:2016 [8]. If equipment and machines are poorly maintained, Velayutham and Dhingira [9] indicate that random breakdowns resulting in unavailability for production or service become the order of the day. On the other hand, Idoniboyeobu and Ojeleye [10] states that if maintenance is effectively executed, it will assist to improve the availability of production facilities, production rate, quality of the service, operation costs, and safety of the operation. These factors will in turn determine the profitability of the enterprise. For this study, maintenance can therefore be summarized as a combination of technical and administrative activities required to retain the equipment to

its original state, in a cost-effective manner, considering the safety, health of the personnel and plant, to ensure the availability and reliability of the plant.

Maintenance function is defined by Maletič et al., [7] as the business decisions and corresponding activities required for the optimization of the production system or machine, for the attainment of desired performance. This function includes formulation of a maintenance vision, strategies, policies, and standards, as well as planning and execution of activities in a way that meets the prescribed technical condition, plant availability, safety of the personnel requirements, environmental requirements, warrants the quality of delivered products and services, and secures the expected service life of individual devices [4] [5] [9].

Juxtaposing maintenance definition and the maintenance function above implies that the maintenance service must be delivered at an agreed service level – i.e., response time, quality of work and costs. This will ensure achievement of required plant availability, ability to guarantee quality of the products, compliance to safety standards and regulations concerning people and environment, and desired equipment durability Foon and Terziovski [5]. This implies that maintenance work must be identified, planned, scheduled, resources assigned (people, tools, material, spare parts, procedures, policies, permit to work, etc.), executed, and, finally, evaluated Velayutham and Dhingira [9]. It can be deduced from above discussion that maintenance department play a vital role within the organization and the critical part of the successful operation of the maintenance function relies on their inter-departmental relations. It is also important for the maintenance function to be reliable and trustworthy as the basis for building inter-departmental relationships.

2.2 Maintenance Challenges

There are numerous reasons why maintenance cannot meet or sustain world-class performance. The most common reasons are insufficient budget, not enough time, lack of support from management and poor maintenance management Foon and Terziovski [5] and poor contract management Greenhalgh [11]. There are also non maintenance activities which take on average between 30% and 40% of the maintenance budget Palmer [12]. Such non-maintenance activities are expected to be executed by the department. Further, Sighn [13] indicated that organizations encounter many obstacles in implementing effective maintenance management resulting in poor plant availability, as such, management must formulate action plans to overcome these challenges.

Furthermore, poor control of inventory can lead to high stock levels and the unavailability of spares Urissa [14] which ultimately hinder maintenance management work. In addition, poor contract management which according to Greenhalgh [11] is hinged on corruption has riddled procurement departments. As such, optimal management of spares inventory and contacts is crucial for effective execution of maintenance activities Foon and Terziovski [5].

Although some have been mentioned earlier, Ntshangase [15] studied maintenance practices of different organisations and established the following challenges:

- Ineffective spares and inventory management
- Lack of production and maintenance technician technical competence
- Ageing equipment and machinery
- Insufficient maintenance budget
- Poor leadership skills.

Apart from the above, staff shortage is another challenge as alluded to by Cheema and Asrar-ul-Haq [16]. The authors indicated that staff shortages result in increased responsibilities and workload for current employees resulting in burnout and other shortcomings which impact on employee's performance and eventually organisational performance. Such organisational staff

shortages have been established by Pembi [17] to be caused by business financial constraints and workforce issues.

2.3 Maintenance Benefits

Foon and Terziovski [5] [4] states that maintenance effectiveness adds value towards the availability and reliability of the plant, improves production efficiency and profit margins of the organization. Maletič et al., [7] further emphasises that effective maintenance increases the competitiveness of the organization and its profit margins. Furthermore, Palmer [12] summarised the benefits as minimisation of downtime, improvement in total availability of the system, safety of personnel and extended useful life of the equipment. To reap these benefits, an organisation must build on core competences. Tayauova [18] states that core competence can be thought of as group of qualities that a business holds of which in return will allow the business to achieve competitive advantage. This is achieved through training which Tismal et al., [19] generally considers as means of enhancing person's skills, knowledge, and capabilities which empowers them to understand business aspects.

2.4 Maintenance Strategies

Each organization has defined maintenance needs due the different types of machinery and equipment requiring different methods of maintenance. This implies that maintenance management and engineering personnel must came up with proper maintenance strategies to be used for different types of machinery and equipment Rani et al., [20]. Based on an organization's budget, number of resources, level of combined experience, and maintenance goals, one or more maintenance strategies are used. Maintenance strategies generally included two approaches namely corrective and preventative maintenance Bakri et al., [21]. Palmer [12] describes preventative maintenance (PM) as the care and servicing of the equipment as per the approved maintenance strategies, to keep equipment in satisfactory operational state by conducting regular inspections, identification, and correction of emerging failures either prior to their occurrence or prior to their development into major failure. Thus, PM is carried out to reduce the probability of failure whilst mitigating degradation [4]. PM system is centred on recommendations made by the equipment original manufacturers, taking history of the equipment and system environment into account Rani et al., [20] and form asset maintenance plan although it requires more money upfront [4]. Seddiqe et al., [22] define corrective maintenance (CM) as a maintenance task performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the required tolerances or limits. CM is also known as repair and replacement, run-to-failure, failure-based maintenance, fire-fighting maintenance, or breakdown maintenance Rani et al., [20]. Depending on the criticality, severity, or impact of the equipment failure on the functioning of the system, maintenance can be done immediately, which is referred to emergent work, or can be deferred, which will become planned corrective maintenance [20]. Some of the limitation of this maintenance strategy include higher long terms costs and increased unplanned downtime [20].

2.5 World Class Maintenance Strategies

Imam et al., [23] defines world-class maintenance (WCM) as a complete system that is created when organizations integrate clear visionary leadership with well-defined processes and supportive culture to ensure that the vision and ownership of proper maintenance procedures infiltrates the organization. Further, Goyal and Maheshwari [24] further define world class maintenance as a relationship between maintenance and production organizations to enhance the quality of the product, reduce waste, decrease manufacturing cost, increase availability of the equipment, and improve the organization's overall state of maintenance. As such, the main goal is to take advantage of performance to gain meaningful advantage over opponents [25].

Several world class maintenance frameworks are abuzz and choosing a particular framework from several frameworks reported in the literature might not be an easy task for the maintenance manager. Felice et al., [26] taking into consideration the different frameworks identified ten management pillars for a maintenance framework namely: safety and health; cost deployment; focused improvement; autonomous activities; professional maintenance; quality control; logistics; early equipment management; people development and environment.

A more optimised world class maintenance management framework adopted by this study was introduced by the Global Forum on Maintenance and Asset Management [4] which contains nine subject groups namely: business requirements and organisational context; asset creation and acquisition; maintenance tactics and task types; asset maintenance strategy development; human and material resource management; maintenance work management; asset performance and condition; maintenance data and information management and maintenance programme management. Implementation of such a world class maintenance framework is of critical importance to improve the maintenance status of the organization to world class standard.

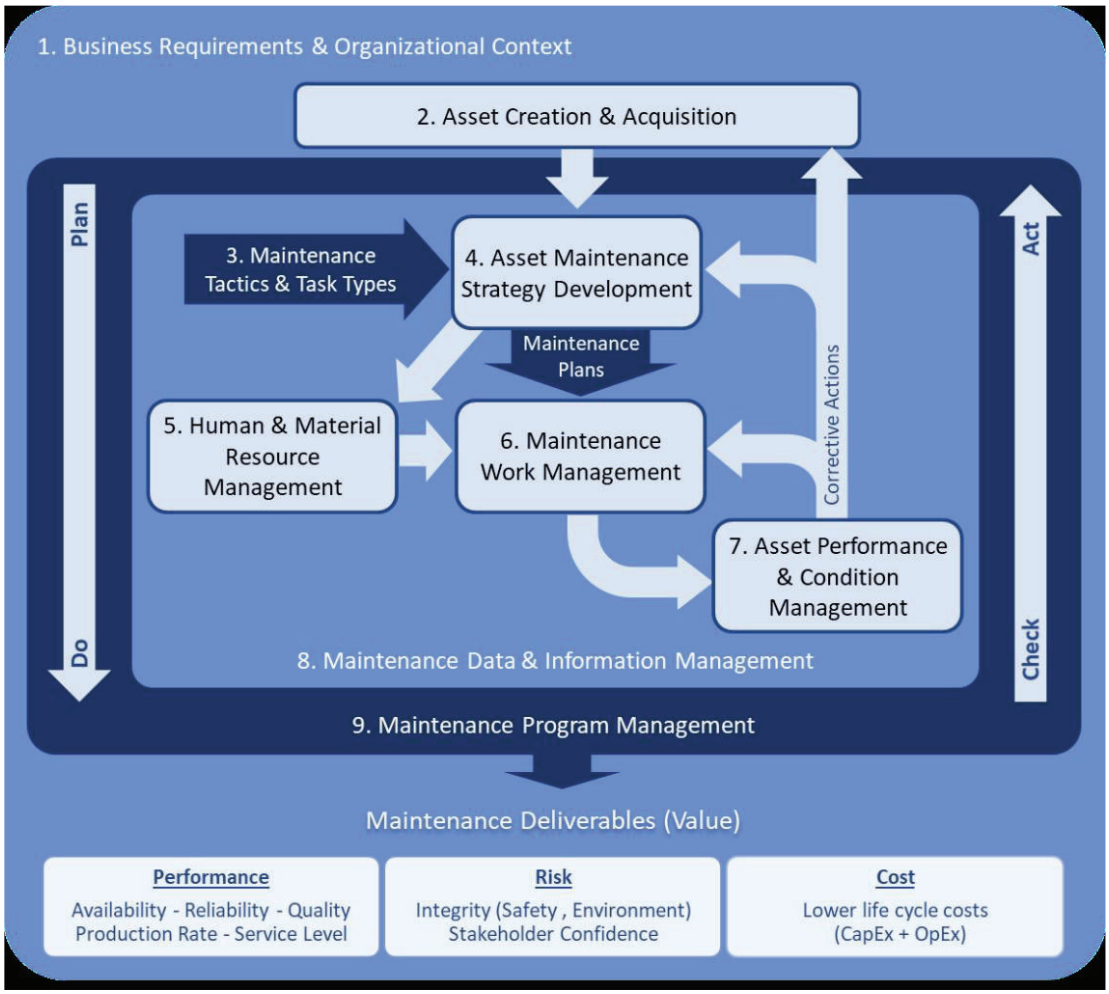

Figure 1: World Class Maintenance Framework, adapted from Global Forum on Maintenance and Asset Management [4]

3 RESEARCH METHODOLOGY

To satisfy the objectives of the study, a qualitative research approach with an interpretivism philosophy was adopted. This allowed the researcher to understand the real-life situations within the organisation [27]. This research focused on 13 out of a total of 150 personnel in the Power utility's Maintenance Engineering department. This was aligned to Cooper & Schindler [28] who recommend a sample size of between four and 15 participants for exploratory qualitative studies.

The 13 consisted of 1 Executive,1 Senior Manager, 2 Managers, 3 engineers, 3 Technicians, 3 Artisans 15. 5(39%) had maintenance management and engineering experience of between 2 - 10 years; 6 (46%) had experience between 11 – 20 years while 2 (15%) had more than 20 years.

Data was collected through semi-structured interviews conducted face to face, or telephonically. Semi-structured interviews yielded rich data, as participants were able to raise their views without the influence of the researcher. Data was recorded to ensure that all the interview discussions were properly apprehended and correctly captured. Data analysis ensured using the six-phase thematic analysis framework format [29]. This allowed for the research questions to be addressed as themes and patterns were established from the data and interpreted [30].

4 FINDINGS

Thirteen participants took part in this study, analysis of the interviews was done according to the thematic analysis process and the following themes and categories were created:

Table 1: Themes, Categories and Findings

Themes	Categories	Findings
Spares Management	Process Deficiencies	Spares management was identified to be major challenge facing maintenance, which hinders the effectiveness of maintenance task execution. *"Unavailability of spare parts is an issue due to the incorrect spares delivered. This is impacted by the source where it comes from"* *"Maintenance is not effective; the plant is more often than not available nor reliable due to defects that cannot be attended to because of unavailability of spares"* *"Procurement process has too much red tape"* *"Due to open tender process end-users are not allowed to go to original equipment manufacturer (OEM)"*
	Spares contracting	Spares management was identified as a challenge. *"Spares availability and accuracy of stock is one of our monsters in maintenance, you find nothing at stores, more than 40% of contracts expire and are not renewed on-time"* *"Reasons for the unavailability of spares are the delays on the procurement process due to lack of*

Themes	Categories	Findings
		resources. The buyers are on contract basis, sometimes their contract expire and is not renewed on time. This result in delays of getting the spares"
Outsourcing	Contract Management	Outsourcing was also identified as one of the major challenges in maintenance. *"Service providers are profit driven, whereas the power utility is production driven. The more there is plant failures, the more they gain. As a result, they do not come up with long term solutions, to gain more profit"* *"Power utility employees lack technical skills and experience to manage the contracts". "Outsourcing is not a problem if the power utility employees must be upskilled to manage contractors better"*
	Contract structuring and governance	Irregularities and inconsistencies in governance and managing of contract were cited as challenges. *"Contractors are not held accountable when they are not performing as per contractual agreement, because staff have conflicting relationship with contractors"* *"Some contractors take time to resolve plant maintenance related issues"*
Training	Lack of experience and technical expertise	Training was established aa a pain for the power utility *"Challenge in maintenance is lack of skills and competencies"* *"One of maintenance challenges is poor workmanship due to lack of skills. There are artisans, who were hired with recognition prior learning process, fact remains that those artisans did not go through the complete training for the artisans' programme"* *"Engineers are inexperienced to draft maintenance strategies, instead they use history and what was done by the previous engineers"*

Themes	Categories	Findings
Human Resource	Understaffing and Recognition	The study identified staff shortages as a contributing factor to maintenance challenges. *"We have lot of preventative maintenance to be done but fewer resources, as a result we are not able to execute all the maintenance tasks diligently and effectively, and this affects our performance"* *"There is no encouragement or motivation for employees to lift up their morale"* *"There is low employee morale due to 0% salary increase and no performance bonus and that has a negative bearing on performance"*
Business Performance	Plant performance Quality	Ageing plant and obsolete equipment poses some of the challenges in maintenance. *"Ageing plant requires more maintenance; thus, spares are required more often than normal, and more people are required to maintain the plant and attend to breakdowns. That results in more overtime requirements due to breakdown caused by ageing plant and staff burnout"* *"Not all maintenance tasks have documented quality control plans, meaning that there are minimal checks on the quality of work done"*

5 DISCUSSION

Theme 1: Spares Management

Non-delivery and delayed deliveries of spares was identified as the most common problem in spare parts management, which leads to unavailability of spares for the execution of maintenance tasks. The reasons cited by the participants was that these challenges were because of unsuitable suppliers, the unavailability of spare parts in the local market and current government policies that supports the local suppliers and not the OEM. The study also revealed that the current procurement procedures and processes are not effective in ensuring the selection of suitable suppliers.

Management and monitoring of stock levels and proper cataloguing of spares at stores, was also identified as one of the challenges in spare parts management. These findings are aligned to what Urissa [14] established in that poor control of inventory can lead to high unnecessary stock levels and unavailability of spares. Foon and Terziovski [5] further states that it is very critical for an organization to ensure optimal management of spares inventory as that will provide assurance to the effective execution of maintenance activities. The study also revealed that spare management challenges were because of poor management of spares contracts and or not having spares contracts in place. In addition, delays in procurement process are impacted by lack of personnel in procurement and material management.

Theme 2: Outsourcing

The study revealed that the business model of outsourcing maintenance activities is not appropriate and brings forth a lot of challenges. This notion was supported by several participants who stated that outsourcing is a suitable business model due to the following:

- In outsourcing, contracts are replaced for a certain period, when the period expires, they are renewed or changed to another supplier. This results in loss of skills and the business also losses its competitive advantage.
- The business is unable to build long-term relationships with the service providers due to the short-term contracts.

The above responses are in line with the literature, which stipulates that the need for core competency to be maintained internally, and that those other activities that are not deemed core to the business, need to be considered for outsourcing [18].

The study also identified concerns about the skills of the employees provided by the service providers. In addition to that, the service providers do not provide training (technical and on job training) to their employees and that there is no succession planning in place. Tayauova [18] established that the disadvantages associated with the inability to control outsourced activities originate from the fact that managing of external resources requires special skills which entails a combination of contract management, power to negotiate, people's skills and process management. In addition, participants raised concerns and frustrations mainly on challenges regarding the application of the processes and procedures, for managing contractor performance. Other challenges cited include cases being reported and investigated with no corrective action being taken, inconsistencies in handling and concluding misconduct investigations and the lack of consequent management for non-compliance with the contract management processes.

Other participants cited personal interest and relationship with suppliers as a contributory factor, which results into intentional failure in effective contract management due to other interests. According to Greenhalgh [11] one of the contributory causes of poor contract management is the corruption that has dominated the procurement department. As a result, awarding of contracts is influenced by some members of the tender awarding committee, evaluation committee, and procurement officers. This has resulted in contractor failures given that the technical ability was not assesses when the contract was awarded [11]).

Theme 3: Training

In coherence with the literature by Ntshangase [15] the study revealed that maintenance personnel are lacking technical experience, knowledge, and skills as a result they cannot effectively execute maintenance activities. The plant is suffering as they are failing to meet the expectations of resolving plant issues make informed business decisions. In addition, the organisation is not empowering employees to make decisions, influence, and effect changes to maintenance programmes.

The study established the high turnover of experienced engineers, leaving engineers in training to carry out the duties. It was highlighted that one of the engineer's roles is to support maintenance personnel in resolving plant issues and to also compile maintenance strategies. This requires experienced engineers with extensive technical skills. Contrary to this, inexperienced engineers are allocated plant systems and expected to perform optimally.

It was also identified that the focus on technical training to enhance employee skills, and to be in synch with new technology has been neglected by the organisation and that there is no provision for formal or proper on job training for inexperienced employees. Tismal et al. [19] generally considers training as a means of enhancing a person's skills, knowledge, and capabilities and to empower them to understand business aspects. If training and alignment to new technology is not happening, the maintenance function will be crippled.

Theme 4: Human Resource

It is evident from participants that staff shortage is prevalent, the impact is aligned to views by Cheema and Asrar-ul-Haq [16]) who stated that shortage of staff increases responsibilities and workload for the current employees, resulting in burnout and other shortcomings which impacts on employee's performance and ultimately organisational performance. Such organisational staff shortages have been established by Pembi [17] to be caused by business financial constraints and workforce issues.

Participants shared their views and concerns on employee recognition. Due to the organisational financial position, all the other incentives or the processes have been put on hold including a moratorium on payment of bonuses, salary increases and external positions. This has a negative bearing as work force issues such as staff shortages, morale, employee engagement, staff-centred factors such as participation, morale, and staff shortages are not only inseparable, but are critical in the performance and effectiveness of an organization [16].

Theme 5: Business Performance

Most equipment has reached its end of life, because of ageing plant and equipment obsolescence which has led to:

- Frequent plant breakdown which requires more maintenance activities and resources
- Spares no longer available in the market
- Skills to maintain the equipment are no longer available resulting in plant breakdown taking longer to repair due to trial and error.

The prolonged plant downtime and shortage of skills impacts negatively on plant availability. Plant breakdown due to ageing requires regular maintenance and more resources. The above statements are in line with findings from Rani et al., [20] and Velayutham and Dhingira [9] and ultimately impact on maintenance management and the financial status of the power utility in general.

Other issues include quality of work execution within maintenance. Quality issues included unavailability of quality control plan and inconsistent quality control on the execution of maintenance activities. The shortage of resources and lack of discipline from the employees were cited as a reason of not monitoring quality control in maintenance. In addition, poor planning of maintenance activities was also identified as one of issues within maintenance. Furthermore, the participants indicated that poor planning results in re-work on maintenance activities, decrease in production due to increase of unplanned and unscheduled repair work and expensive shutdowns, or costly repairs.

6 MANAGERIAL IMPLICATIONS AND RECOMENDATIONS

Leadership, and management of the Power utility can make use of the following recommendations are generated from this study:

World Class Maintenance

The power utility is recommend adopting the world class maintenance framework with nine subject groups and propagated by the Global Forum on Maintenance and Asset Management [4]. The proposed framework will be beneficial for the maintenance function as they strive to be the best in the global scenario. Further, this framework must be implemented and monitored following the seven-step approach highlighted by Arsovski et al., [27].

Outsourcing

It is recommended that the business must evaluate the benefits and reputational risk of outsourcing of maintenance works balancing with the effectiveness and efficiency of managing

maintenance functions. This must be done with the understanding that core functions relating to turbo generator maintenance should not be outsourced.

Human Resource Strategy - Manpower and Skills

- To close the skills gap, the power utility must conduct skills audits and training needs assessments within maintenance teams and maintenance training standards. These documents will provide a clear guideline and opportunity for the maintenance employees to be trained with appropriate skills, qualifications, and experience to manage and execute maintenance work optimally. Skilled maintenance personnel will assist in proper issue diagnosis, the planning maintenance intervention, and the effective and efficient execution of activities.
- Institute an organisational design model for optimal maintenance department structure and the requisite capacity planning for its optimal resourcing.
- Explore and make use of the modern technology e.g., computerised maintenance management systems for the execution of maintenance task to address the issues of staff shortages.

Spares Management

- Greater inventory control should be implemented and strict measures to be put in place to address the performance issues at stores as it will result in better procurement and management of spare parts.
- Identify the list of spares to be on contract and establish spares contract to minimise errors and delays on tendering process. Ensure a balance between material resource requirements held as inventory on site or elsewhere through the using of different stoking methodologies considering cost effectiveness and performance.
- To purchase spares from the original equipment manufacturers where possible, to reduce cost and build a better and more cohesive supply chain. Proper storage of spare parts would be considered as damaged spares compromises plant availability and reliability

Contract Management

- Review existing systems, policies and procedures related to contract management and its governance to identify any potential failures or deficiencies. In addition to that (a) preserve an ethical tone and in still a culture of honesty throughout the contract management process and the organisation at large; b) provide fraud prevention systems, processes, and training and (c) ethics training for employees in positions that are subjected to corruption which can be extended to all employees and (d) conduct regular effective contract management process evaluations and audits.
- Conduct an assessment on the existing contract to establish the duplicated resources, and thereafter devise a plan of integrating the contract to eliminate such duplications.

Plant performance

- Quality management system should be enhanced by ensuring the appropriate identification of critical activities, quality controls for such activities to be in place and close monitoring of quality control implementation be in place. The organisation is ISO 9001: 2015 certified and should adhere to the different provisions of the standard in ensuring an optimised quality management system.
- The plant modifications and projects should be initiated and or fast tracked to ensure the plant is aligned to current technologies thereby enhancing ease of maintenance. Interlinked to this is the need for data driven decision making which are however dependent on the organisation's ability to institute and manage a data management

system. Such maintenance data must be managed real time and converted to knowledge after which it will be used in the management of maintenance activities.

- There must be incentives for performance and sanctions for non-performance in the maintenance department.
- Maintenance audits and benchmarking must be mandated and driven as part of continuous improvement in maintenance function, and lessons learnt should be shared across the whole power utility.

7 CONCLUSION

The study concludes that the challenges facing the power utility relate to the following: process deficiencies, spares contacting, contact management, contract structuring and governance, lack of technical expertise, understaffing challenges, ageing plant, and obsolescence of equipment. In addition, the study confirm that effective maintenance execution enhances performance of the organisation. Recommendations have been made relating to the human resources strategy, spares management, contract management and plat performance for improved ad optimised maintenance management department to ensure the organisation drives towards maintenance excellence.

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