ENVIRONMENTAL RISK ASSESSMENT FOR THE ELECTRICITY SECTOR:

A CASE OF SWAZILAND ELECTRICITY COMPANY

by

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DECLARATION

I Constance van Zuydam hereby declare that Environmental Risk Assessment For The Electricity Sector: A Case of Swaziland Electricity Company is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references. The thesis has not been submitted or will not be submitted to a University or any institution for the award of a degree.

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ABSTRACT

The provision of reliable, safe, affordable and accessible power supply is one of the most important cornerstones for economic development, particularly for third world countries. Notwithstanding all known benefits of power supply, there are environmental risks associated with electricity generation, transmission and usage that need to be identified, assessed and managed. These risks range from minor to major risks such as serious bodily harm and fatalities as well as environmental degradation. In order to minimise and control the operational risks, it is key for the sector to ensure that the risks are identified and assessed using appropriate tools and systems to ensure sustainability and safe work environments. This study explored, improved and designed a tool for environmental risk assessment within Swaziland Electricity Company, (SEC) based on clause 4.3.1 of ISO 14001 (2004), Environmental Management System and Occupational Health and Safety Assessment Series, OHSAS 18001 (2007), Occupational Health and Safety System. The previous risk assessment and evaluation tool used in the company ignored existing risk control practices employed and thus did not truly quantify identified risks.

The methodology presented in this study focused on the identification of hazards/aspects and risks associated with processes in electricity generation, transmission and distribution. Risks were evaluated and all possible measures to control the identified risks were suggested.

The top three significant hazards identified include; exposure to live wires, road hazards and the use of uncertified/ defective/wrong equipment and/or machinery whilst the significant impacts were: soil pollution, natural resource degradation/ depletion, loss of flora and fauna and social impacts. The distribution department was observed to have the most environmental risks when compared to the other departments. The developed tool and data could be used as baseline information by other sectors wishing to implement environment and safety systems. It will also continually improve the safety and environmental performance of SEC.

Key words: hazard, hazard identification, risk assessment, OHSAS18001 (2007) Occupational Health and Safety Management System, ISO14001 (2004) Environmental Management System, risk, risk analysis, risk management, electrical hazards, environmental risk assessment, aspect

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May the Almighty bless you all.

GLOSSARY LIST

ALARP	As Low As Reasonably Practicable
CDM	Clean development mechanism market
CEAA	Canadian Environmental Assessment Act
COSO	Committee of Sponsoring Organisations of the Treadway Commission
EA	Environmental Assessment
ECA	Economic Commission for Africa
EDM	Electricity De Mozambique
EIA	Environmental Impact Assessment
EMS	Environmental Management System
EMA	Environment Management Act
ERA	Environmental Risk Assessment
ERM	Enterprise Risk Management
ESKOM	Electricity Supply Commission
FMEA	Failure Modes and Effects Analyses
HIRA	Hazard Identification and Risk Assessment
HSE	Health Safety and Executive
ISO	International Organisation for Standardisation
ISO IEC	International Organisation for Standardisation by the International Electrotechnical Commission
MoF	Ministry of Forestry
OH and S	Occupational Health and Safety
OHSAS	Occupational Health and Safety Assessment Series
OSHA	Occupational Safety and Health Administration
OHSA	Occupational Health and Safety Act
PPE	Personal Protective Equipment
QMS	Quality Management System
QRA	Quantitative Risk Estimation
SADC	Southern Development Community
SAPP	Southern African Power Pool

SCADA	Supervisory Control and Data Acquisition
SEA	Swaziland Environment Authority
SEC	Swaziland Electricity Company
SECIES	Swaziland Electricity Company Information Engineering Standards
SEPA	Scottish Environment Agency
SHERQ	Safety Health Environment and Risk and Quality
T and D	Transmission and Distribution
USEPA	United States Protection Agency
USNRC	US National Research Council

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1 CHAPTER 1: INTRODUCTION

1.1 Background

The electricity industry is one of the most important sectors of the world's economy and for economic development. Although vital to economic development, due to the way it is generated, transmitted and utilised; many risks are posed to the environment, to the people working on it, to those that come in contact with it and the end users. These risks range from minor to major risks such as serious bodily harm and fatalities as well as environmental degradation. In order to minimise and control the operational risks, it is necessary for the sector to ensure that the risks are identified using appropriate tools and systems to ensure sustainability and safe work environments. This work will explore and design a tool for environmental risk assessment within Swaziland Electricity Company (SEC).

The first chapter of the work presents background information to the research area and outlines the problem that the study seeks to address. The aims, objectives, justification and methodology of the study are presented in this chapter It also outlines the structure of the thesis.

1.2 The Electricity Industry in Swaziland

Swaziland Electricity Company (SEC) formally known as Swaziland Electricity Board was established in 1963, and is the sole provider of electricity in Swaziland wherein it generates, transmits and distributes electricity. SEC operates mainly four hydropower stations – namely the Maguga, Ezulwini, Edwaleni and Maguduza hydropower stations. The Maguga hydropower station obtains its water from the Maguga dam, which is supplied by the Komati River. The other three hydropower stations are cascaded and are all supplied with water from the Lusushwana River. The stations have an installed combined generation capacity of 60.4 Mega Watts (MW) and serve as peaking and emergency power stations. This is because there is limited dam storage capacity, variable rainfall patterns and intensity to enable consistent generation output. Therefore, there is not enough water to drive the hydropower plants all year round to supply the country's energy demand of 210MW. The company thus imports 80% of the total electricity requirement from Electricity Supply Commission (ESKOM) and Electricity De Mozambique (EDM). This is unsustainable since the country only generates 20% of its demand (SEC, 2012).

1.2.1 Electricity generation

The electricity generated from the four power stations is clean and renewable energy. It is generated from water released from dams which has potential energy that is converted to electrical energy. The water flows from the dams through penstocks which are high pressure conduits into water turbines. It then passes through a turbine runner and turns the turbine shaft which drives the generator connected to it, hence generating electricity. The water is then discharged back to the river and the electricity generated therein is fed into the transmission network as shown in Figure1.1, (SEC, 2016).

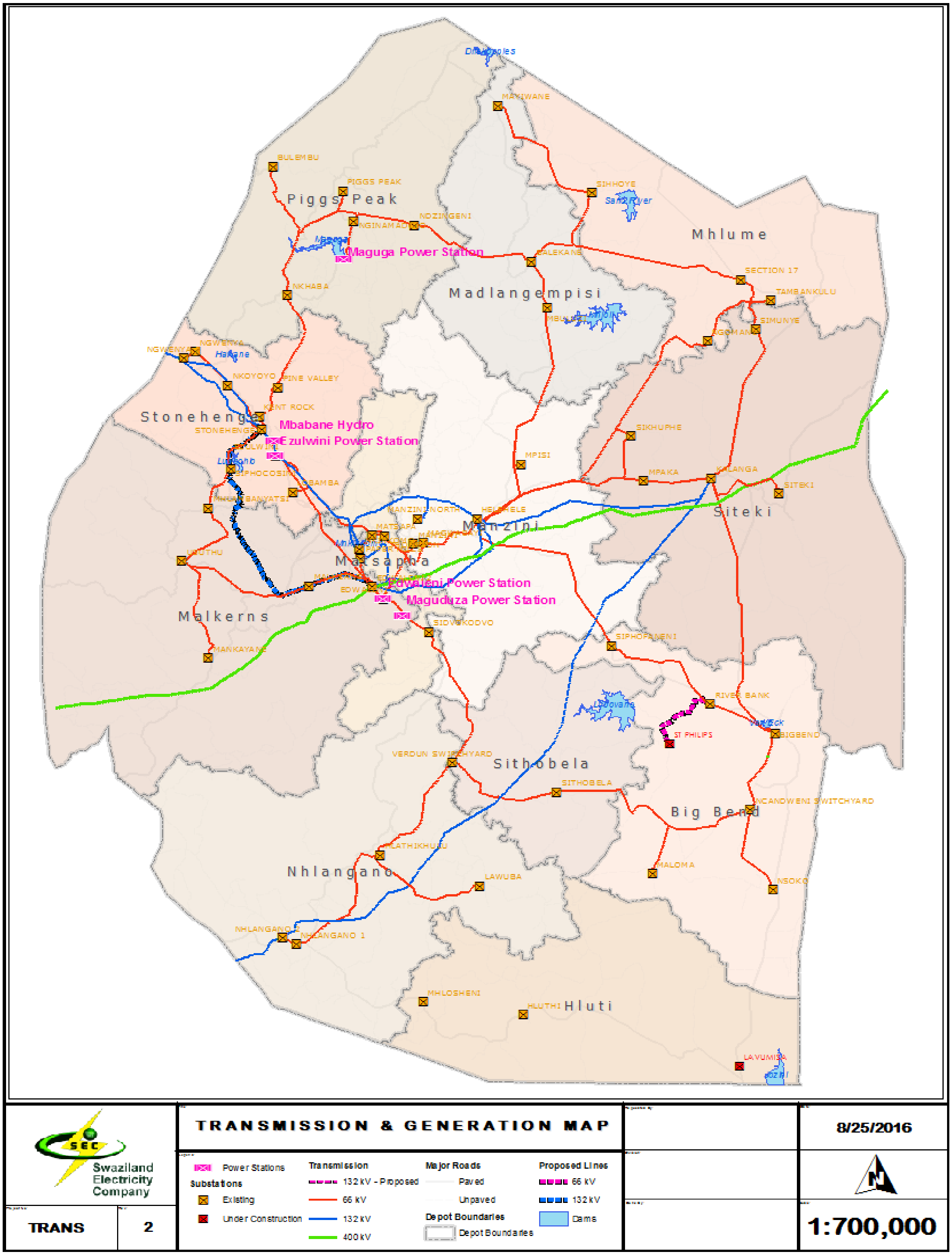


Figure 1: Transmission, Generation and Distribution network at SEC (SEC, 2016)

1.2.2 Electricity transmission

The company has 54 substations and different transmission lines ranging from a 400 kV line that runs through the country from South Africa to Mozambique; to 132 kV lines and 66kV lines. The lines are monitored or controlled using a Supervisory Control and Data Acquisition (SCADA) system in control centers, (SEC, 2012).

1.2.3 Electricity distribution

Electricity is then transmitted to over 110 000 customers all over the country through 11 kV lines and is obtained by customers in prepaid meters. This electricity network covers 70% of the country's total population and it is fast growing. The country's household access rate is estimated at 40%. However, it is increasing due to rural electrification projects funded by the country's developmental partners, the Republic of China, Micro projects (through the Ministry of Economic Planning and Development), and regional development funds. According to the Southern Power Pool (SAPP), SEC is amongst the top five utilities which have achieved excellent electrification in their countries (SEC, 2012). The increasing electrification has to cope with challenges that include highly dispersed population dynamics, poor terrain and the fact that a greater portion of the electricity is imported from neighboring countries. Measures to be taken include energy saving, diversification of sources and promotion of renewable energies.

As the SEC is trying to meet the ever growing demand for electricity, there are potential risks associated with construction of new generation plants, maintenance of existing infrastructure, expansion of the network, ensuring efficient energy use and the exploration of new technologies. Therefore, elements such as risk control, safety, health and environmental management, can no longer be left out of the equation, particularly when the company plans to increase network coverage to meet the demands on growth. There are also legal requirements from the country that require organisations to ensure environmental sustainability and minimize health and safety risks. According to the Swaziland Environmental Assessment Audit Review Regulation (2000), an integrated Health, Safety and Environmental risk assessment has to be undertaken prior to construction of any project as well as when existing infrastructure is extended. The Swaziland Occupational health and safety act (2001), also requires that companies identify and carry out risk assessments to minimize occupational health and safety risks to employees.

1.3 Statement of the Problem

Electricity is more than energy; it is a vital component of infrastructure and an essential part of modern day life (Nordgård, 2010). It plays a critical role in the economies of most countries. Electric power has become a prime mover for productivity, wages and jobs throughout the world, as well as the lifeblood of what is now being referred to as the new global economy. Electricity is one of the energy sources which are a pre-requisite for the technological development and the economic growth of a nation. It is the cornerstone of ensuring energy security for any country (Mondal, 2010). The demand for electricity in Southern Africa has grown by about 3% per year since 1998 mainly because of positive economic growth mostly in South Africa, Botswana and Namibia, rapid urbanization, population growth and the expansion of rural electrification programs (ECA, 2006). The increase in demand means the need for generating and transmitting more electric power which then means more risks that need to be identified, assessed and managed.

It is very important for a company like SEC to take proactive approach to predict and manage risks rather than to take reactive approach when undesirable situations occur. According to Nordgård (2010), in the last 10 to 15 years electricity companies throughout the world have been ever more focused on asset management as the guiding principle for their activities and not much has been dedicated to managing risks. Over the recent years however, there is now an increased awareness of the need to include risks into the electricity utility decision making processes.

Darbra *et al.,* (2008) states that the growing concern about the environment and the potential risks associated with many human activities and new technologies have created increasing interest in environmental risk assessment, a critical, essential tool in any decision making process in business. Thornton (2009), also notes that, failure to effectively incorporate and manage risks can more often, lead to serious consequences to a business such as damaged reputation, loss of profits, disruption of productivity or at worst, business shutdown. Supporting the above statement, Sand *et al.,* (2007), highlights that intangible risks (safety and environmental) may have a significant impact on company reputation. It is therefore, essential for the electricity sector to identify such risks and evaluate as well as control them.

This study, therefore, seeks to conduct an environmental risk assessment for the electricity sector, using SEC as a case study. The Swaziland Electricity Company (SEC) has decided to review its strategy against the backdrop of prevailing operating conditions, mandate and market conditions. One of the company's strategic objectives is to ensure effective management of enterprise wide risk, mainly focusing on intangible risks (health, safety, environmental and quality risks) and conformance to SEC policies and procedures. This also ensures compliance to relevant local and international standards and norms as well as to provide various value added support services to SEC divisions. The company has thus set a strategic goal of improving Safety, Health, Environment and Quality risk by implementing three internationally recognized management systems. These are International Organisation for Standardisation (ISO), ISO 9001 (2008), a Quality Management System (QMS), ISO 14001 (2004), an Environmental Management System (EMS) and OHSAS 18001 (2007), which is an Occupational Health and Safety Assessment Series. The company attained certification to these standards in the year 2014 and 2015.

In order to focus on environmental risk, safety and health risk in the electricity sector, this study will use the two systems ISO 14001 (2004) and OHSAS 18001 (2007). Tools appropriate for the management systems will be used to identify risks in the electricity sector, evaluate their significance and propose mitigation measures and / controls. The assessment will include health and safety as well as environmental significant risks associated with the processes in the electricity sector.

1.4 Justification

One of the most pressing challenges organisations face today is to operate in an economically, socially and environmentally sustainable manner. Concerns such as overconsumption of resources, climate change and destruction of ecosystems will contribute to the shift in the economy and society fundamentally (Hopwood *et al.,* 2010). Finergy, (2002) states that electric utility companies, which mainly generate, transmit and distribute electricity, are a vital, omnipresent part of society and the environment. They provide a vital role in generating welfare and economic prosperity and play an important part in economic development. However, the electricity industry involves many processes and operations which are associated with various risks. Sand *et al.,* (2007), documents such risks as; economic, safety, environmental, quality of supply, reputational, vulnerability and regulatory risks. The issue of risk management is therefore, critical in the electricity sector in order to ensure improved efficiency and reduced risks during provision of electricity service.

This study is motivated by the fact that when reviewing literature it was observed that many studies undertaken worldwide in the electricity sector, focused mostly on financial risks and other risks that were managed in silos. Intangible risks such as the environment, health and safety have not been given much attention. According to Sand *et al.,* (2007), this is a major challenge because these risks also have a bearing on the company's costs, performance and reputation. Hence, the need to find and develop novel methods to analyze and evaluate intangible risks cannot be overemphasized. This is the main objective of this research project; to close the gap and contribute innovative way to determine and evaluate the intangible, safety and environmental risks in the electricity sector.

Secondly, with respect to the situation in Swaziland, literature indicates that there has been no study undertaken in the Kingdom which looks at the assessment of environmental risks in the electricity sector. This is a major challenge since Swaziland is faced with energy crisis and environmental degradation (SEC, 2012). At present, the country can generate about 60 MW of electricity, while peak demand is about 210 MW. With an 80% power dependency on ESKOM, SEC is locked into a dependency syndrome with few viable or quick alternatives (at this point in time). This leaves the organisation vulnerable to disruptions in power supply and potential exploitation by competitors. This is a clear indication that more power challenges in the country will manifest in the form of load shedding. Therefore, SEC needs to move towards proactive control over its assets, resources, markets, electricity and new, alternative power supplies as well as internal and external risks from the various operations.

This study ensures that the electricity sector complies with environmental and health and safety legislation in line with environmental risk assessment. These are the Swaziland Occupational Health and Safety Act (2001) as well as the Swaziland Environmental Audit and Assessment Review Regulation (2000) which, require that organisations conduct risk assessments prior to the implementation of any project (for normal, abnormal and emergency situation).

A further justification of the study is the development of a user-friendly understandable environmental risk assessment tool to cater for safety and environmental risks specifically for the electricity industry processes. This tool helps the organisation to easily develop proactive and integrated strategies for managing environmental risks holistically which will be understood by all employees from top management to general workers. The knowledge of the critical areas that would have an impact on an organisation's safety and environmental profiles improves on performance, as these issues receive more attention once they have been evaluated and rated. It is therefore planned that the tool to be generated in this study will be made available to other electricity utilities; thereby contributing to the body of knowledge.

1.5 Aim of the Study

The main aim of this study is to conduct an environmental risk assessment and develop an innovative environmental risk assessment tool for the electricity sector, using SEC as a case study.

1.5.1 Objectives

In pursuit of the main aim of this study, five specific research objectives were established;

i. To determine significant environmental risks associated with the electricity sector in all processes from generation, transmission to distribution of electricity.

ii. To determine current and introduce possible strategies and best practice to mitigate the environmental risks.
iii. To develop an environmental risk assessment tool for operations in the electricity sector.
iv. To test, analyze and validate the environmental risk assessment tool developed,
v. To make recommendations on further improvements on risk assessments and future research opportunities.

The thesis is structured into seven chapters. The paragraphs below highlight the elements within each chapter, and demonstrate how these relate to the research objectives above.

1.6 Outline of the Thesis

Chapter 1

This chapter provided background information for this research. It summarized the research problem, aims and objectives of the study as well as the significance and contribution of the research.

Chapter 2

This chapter built theoretical foundation for the research by reviewing literature and previous research. This review covered a variety of relevant topics including history of risk assessment, environmental impacts, and existing methods of environmental risk assessment. The working definition of environmental risk assessment applied to the energy sector was provided. The chapter examined the risks of the electricity sector activities on the environment.

Chapter 3

Whilst the previous chapter focused on the broader discussion of environmental risks, this chapter concentrates on the two standards OHSAS18001 (2007) and ISO14001 (2004) which were used in the electricity company to assess risks. The concept of risk assessment and use of OHSAS 18001 (2007) and ISO 14001 (2004) to determine risk are discussed.

Chapter 4

Following the review of literature in chapters 2, 3, this chapter provided an outline of the research methodology adopted when undertaking the research. Arguments were presented justifying this choice of approach and the specific research methods applied to collect data. The data collection process was detailed in this chapter.

Chapter 5

The environmental risk assessment tool for operations in the electricity sector was developed in this chapter. As part of the research, the tool was applied and tested in the generation, transmission distribution and support services department teams. A site was chosen from all the three company core business operations. This chapter dealt with the development and application of methodology for environmental risk assessment in the electricity sector

Chapter 6

The results chapter presented the key findings of the research. A brief interpretation of data was given as well as a discussion of any significance trends observed in the data. The tool was tested and used to show that it can be used as an alternative to current methods.

Chapter 7

This chapter summarized the research and stated the conclusions. Conditional statements are made with respect to the application of the risk assessment tool developed and used in the study. Recommendations for further research are made at the end of the chapter.

1.6.1 Research Approach

The research had various components described as follows;

This research involved both quantitative and qualitative data. A literature search involved a thorough review of current practices and previous research in the area of environmental risk assessment. The basic sources for the collection of the secondary data for this study included scientific databases and journals related to the topic of research as well as reports and publications from electricity industry and governmental agencies. Annual reports were the best way to obtain true and fair view information about the company. They provided a true account of the company's structure and organisation (such as the nature of business, annual turnover and risk management approach) in order to create value to the business entity. In addition, data was collected using questionnaires. These were administered to head of departments and managers. To obtain a better understanding of the business units (generation, transmission, distribution and support services) activities and their environmental risks, on-site observations were done. In the onsite observations the potential risks were identified with team members. Team members were selected based on their specific level of expertise and assisted during the walkthrough of their facility and operations.

To achieve the objective of the study, the methodology was formulated in three phases. The first stage was hazard or aspect identification in the various processes within the company. The identification was followed by the rating of aspects and hazards. Mitigation measures were then identified for impacts resulting from the aspects or hazards. The residual impacts were also determined and rated. The flow diagram below (Figure 1.2) demonstrates the approach used in the study.

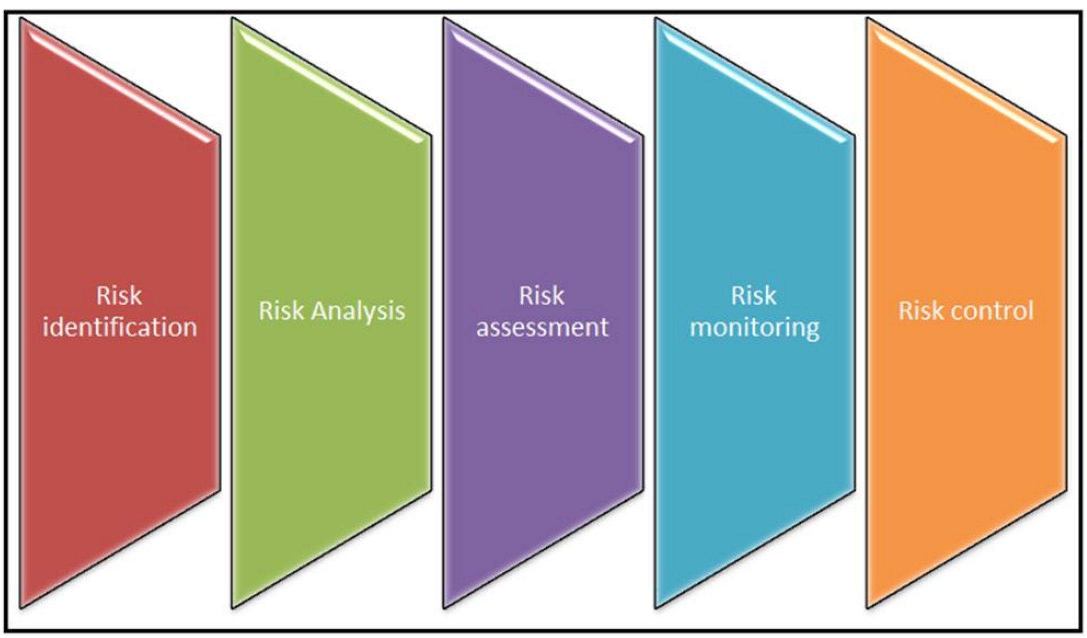


Figure 1.2: Risk management approach

2 CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter gives a brief discussion on the evolution of risk assessment and environmental risk assessment concepts. It also gives an overview on risk assessment and tools of risk assessment. Lastly, the types environmental risks in the electricity sector which is the focus of this study are defined in this chapter. The risk assessment tools to be used in this study are explained and how risk assessment is applied in the electricity sector.

2.2 Background

Electricity plays a major role in providing basic services and meeting basic human needs, such as jobs, food, running water, sanitation, education and health services. Addressing these issues, inevitably involves an increase in the level of electricity service. The electricity infrastructure is therefore very vital to modern society. This electricity is transmitted for consumption through electrical transmission and distribution (T and D) lines. The nominal voltage in bulk transmission lines can be as high as 750 kV, which can cause instant death when contact is made (Short, 2004). Workers involved in the construction and maintenance of these electrical T and D lines are at extremely high risk of electrocution.

In South Africa, the production of electricity is largely from coal. This type of electricity production is the key factor in what is seen as the most serious environmental threat facing the world today – global warming and related climate change effects. Sand *et al.,* (2007), state that the management of such electricity systems and infrastructure consists of balancing cost, performance and risk, taking into account different aspects such as economic performance, quality of supply, safety and environmental impacts.

In addition Kennedy (2008) states that constant power supply is a measure of developed economy and any nation with unreliable power supply are prolonging their development. Developing countries are facing extreme electricity shortages. The Southern Africa Development Community (SADC) is currently facing a power crisis; hence the Southern

African Power Pool for instance has had to come up with mitigatory measures (SAPP, 2012). Two options have been identified to improve energy efficiency and use as well as the search for alternatives sources of energy replacing fossil fuels. As a result, energy efficiency and renewable energy have been explored as substitutes for fossil fuels, leading to the concept of sustainable energy.

One of the critical challenges which electricity utilities and other organisations are facing today is to operate in an economically, socially and environmentally sustainable manner. Hence tools such as conducting environmental impact assessments and risk assessments play a key role in industry in order to attain sustainable energy management. According to Harrald *et al.,* (2006), managerial strategies such as environmental risk assessment can be properly used as a tool in order to achieve sustainable development.

It has been observed that many organisations from various industries have recognized the increasing importance of risk management and have established risk management departments to control the risks they have, or might be exposed to. Akintoye and Mc Leod (1995) for instance mention that the construction industry and its clients are widely associated with a high degree of risk due to the nature of construction business activities, processes, environment and organisation. The electricity industry is not exempt from these construction risks.

2.3 History of risk assessment

According to Barnard (2005) the first written statements on risk management can be traced back to Henry Fayol who, in an article dated 1916, listed six basic functions that should be included in risk management.

At that stage he called it "security", but as time went by, a new concept would take root, which is more commonly referred to today as “the risk management discipline.” Snider (1991) states that the first major international company to recognise and implement the concept of risk management was Massey-Ferguson. They published the first known policy statement on risk management in 1966 which was used internationally in their operations. This introduced the risk assessment factor worldwide. Whilst Simu (2009), states that the starting point of risk assessment in research as a separate field was as a concern for the environment and safety management in the workplace associated with operational activities. The awareness that attracted the attention of the general public in the early 1960s led to increased legislation to minimize the risks on human health and safety. This in turn led, to increased interest from the leaders of industry to analyse risks in their businesses. The development of what is now known as project risk management emerged in the large engineering projects in the energy sector in the mid-1970s; they included BP's North Sea projects and pipelines in North America. The development continued in a diversity of business sectors where large projects were run. In this period from the mid-1980s until early this century, project risk management focused on finding the common structures for all projects and identifying the different approaches that were needed for each project (Chapman and Ward, 2003). The development that is currently taking place in the field of project risk management is focusing on extending the focus to include the wider scope of uncertainty management (Ward and Chapman, 2003) to incorporate the aspects of individual and cultural influence (Hillson and Murray-Webster, 2005) and the social construction of risk (Stahl *et al*., 2003).

2.4 Origins of environment risk assessment

Environmental Risk Assessment (ERA) is a powerful technical and analytical set of instruments for analysing adverse environmental impacts, and has found some application in supporting the decision-making process over the last two decades. It is an important component and useful technical method of Environmental Impact Assessment (EIA), as it helps to evaluate, prevent and alleviate extremely adverse environmental impacts. In this way, it can provide scientific evidence for environmental decision-making, and therefore has been widely applied across the world over the past several decades (Eduljee, 2000). It is a process that evaluates risks to the environment caused by human activities and natural disasters, it also assesses the appropriate level of precaution and interrelated risk management measures to reduce and mitigate hazards, and their adverse impacts so as to achieve an acceptable risk level (USEPA, 2003). One of the advantages of this process over a more traditional environmental impact assessment approach is that it allows potential environmental hazards or threats to be considered on the basis of level of potential risk to the environment.

Environment Risk Assessment (ERA) has made great progress, and developed many approaches and methods over the past several decades. Although the formal assessments of environmental risks from toxic substances to human health in ambient and occupational settings have been conducted since the 1930s, a systematic and overall quantitative approach to ERA can be traced to the work of US National Research Council (USNRC) in 1983. The 1980s and 1990s saw great strides in developing and improving tools to apply in environmental risk assessment (Paustenbach, 1995). The advent of computer-assisted modeling and data handling techniques had transformed the conduct of ERA in the 1980s and 1990s.

As a technique, ERA has developed from human health risk assessment and has been subsequently extended to other environmental problems, including accident risk assessment, natural disaster risk assessment, ecological risk assessment and regional comprehensive risk assessment. With the development of decision analysis techniques, the application of ERA has widened since the late 1980s to provide scientific evidence for environmental management, (Eduljee 2000). The use of ERA has developed from single types of risk assessment to regional comprehensive risk assessment, and recently in its widest application of supporting environmental decision making process (Wu, 2012).

Environmental risk assessment is an essential step in the development of solutions for pollution problems and new environmental regulations. China for instance is approaching an important era in this field; there has been a review of the present laws and of the technical frameworks for environmental risk assessment. This has been of tremendous significance because they can identify the problems with the current system and help the government to establish a more scientific environmental risk assessment system and technical framework. The field of environmental risk assessment has developed rapidly, as a result, the laws, guidelines, and standards have gradually improved, making the assessments more standardized. According to SEPA (2004), guidelines such as the Technical Guidelines for Environmental Risk Assessment for Projects were developed and any construction projects that were sanctioned after 2004 required an environmental risk assessment as part of the environmental impact assessment. In 1990, SEPA (1990) required an environmental risk assessment to account for the possibility of potential environmental accidents. According to the SEPA regulations, both new projects and expansions of old projects with a significant chance of accidents (e.g., chemical, petroleum, nuclear and pharmaceutical industries) should be assessed in terms of their environmental risks as part of the project's overall environmental impact assessment.

2.5 The Concept of Environmental risk assessment

Environmental risk arises from the relationship between human activities and the environment whilst ecological risk management deals with risks associated with past, present and future human activities on flora, fauna and ecosystems. It is a sub-set of environmental risk management (Fenn and Green, 2010).

In Canada, ERA was conceived to provide a focused, risk-based approach to environmental assessment (EA). The approach was designed therefore to be aligned with applicable Canadian regulatory requirements at the time such as the now superseded Canadian Environmental Assessment Act (CEAA), particularly for screening level EA.

This ERA framework provides a basis for rigorous but focused environmental assessment that meets the diligent requirements of EA legislation even where there is potential for high consequence environmental effects. Its key advantage is that it provides a simple but comprehensive framework for justifying and framing scoping that is carried through into the environmental effects assessment. It uses terminology and an approach that is more transparently risk based than conventional approaches to EA. The framework provides a logic basis that is transparent, concise, and understandable. This facilitates meaningful engagement of stakeholders and a rational basis for decision-making. The methodology is appropriate for a range of projects in different environments.

2.6 ERA approach / Methodology

ERA was conceived to provide a focused, risk-based approach to environmental assessment (EA) and strategic EA. It employs a knowledge-based, qualitative risk matrix adapted from a planning tool used by industry to assess a variety of safety, health and environmental risk scenarios. The tool provides detailed, systematic assessment of environmental risks by estimating the probability or likelihood of occurrence and severity of the consequences of incidents for a proposed project, projects or activities. The ERA must assess all environmental effects including those arising from accidents and malfunctions, and cumulative environmental effects. This is the approach that will be used in this research.

The assessment of environmental risk from a project or activities should be implemented by a team consisting of a diverse range of relevant operational and environmental experts. The project description, to initiate the environmental assessment process and describe the facilities and activities associated with the project. Depending upon the nature of project activities, it will be necessary to describe each phase or group of activities as appropriate and potential accidents and malfunctions. Emissions, discharges and wastes should be described. Mitigation measures should be described for each phase or activity (Geoffrey *et al.,* 2013). Figure 2.1 presents a summary of the environment risk assessment process adopted from MoF risk assessment framework (1999).

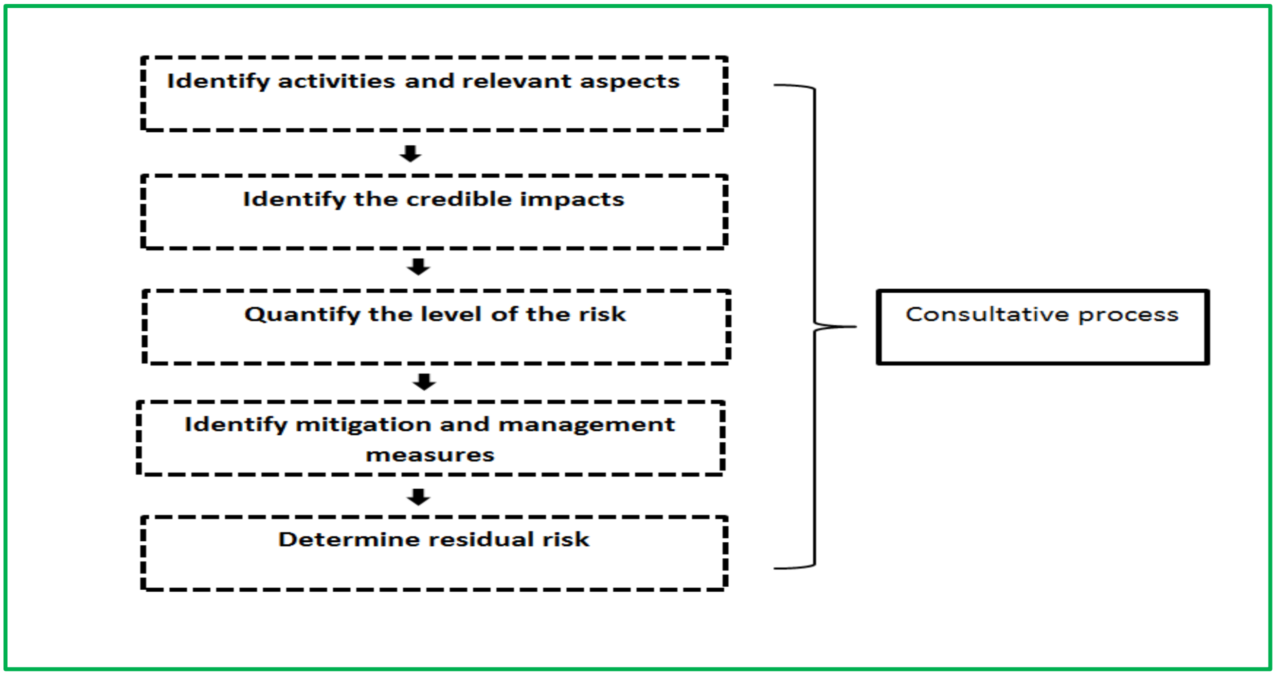


Figure 2.1: Environmental risk assessment process (adopted and modified Ministry of Forestry (MoF), 1999 Risk management framework)

2.7 Definitions of key terms

There are challenges within the risk management field with regards to definitions and principles used in the field. Hence there is a need to clearly define terms since they are used differently in various countries, industries, sectors and fields. Below are definitions of some of the terminology used in the field.

2.7.1 What is Risk?

Risk is defined as the influence of uncertainty on the attainment of goals (ISO 31000, 2009). It is defined also as inherent in the activities of man and all enterprises. Risk is a combination of an occurrence of a hazardous event or exposure and the severity of injury or ill that can be caused by the event or exposure (OHSAS 18001, 2007). Traditionally risk has been defined as a measure of the probability and severity of adverse effects. For the purpose of this study, risk is a probability of occurrence (likelihood) of an event and the magnitude of its consequence and exposure.

Hitchings and Wilson (2002) have examined risks at project level; they have acknowledged the proposal that recognized three areas of risk: (1) Risk to the health and safety of people, including personal injury and loss of life, (2) Risk to the environment, including pollution, damage to plants and animals and soil erosion, and (3) risks to the activity (i.e. project or investment), including damage to equipment, loss of output, and resultant contractual delays and penalties. They have further stated that these areas are joined by a cost that influences the decision about the amount of money and time that should be consumed to reach the accepted level for mitigating risks. The above three areas of risk will be considered in this study.

2.7.2 What is a hazard?

According to Occupational Health and Safety Assessment Series (2007) a hazard is defined as a source or act with a potential for harm in terms of human injury, or ill health or a combination of these. Health and Safety Executive (HSE) (2004), defines a hazard as any source of potential damage, harm or adverse health effects on something or someone under certain conditions at work. Under this definition, a hazard could be a substance, an item such as a piece of machinery, a work method, aspects of the work organisation, the circumstance, an event, an activity which has a potential for harm. Generally, a hazard is often associated with a condition or activity that, if left uncontrolled, can result in an injury or illness. In this study, hazard refers to any activity or situation that has the potential to cause harm to people, environment and property.

2.7.3 What are Aspects?

Environmental aspects are those elements of the organisation's activities, which can interact with the environment and bring change to the environment whether positive or negative, for example energy consumption, or oil spillage from a transformer or disposal of creosote treated wood poles.

2.7.4 What is an environmental impact?

Environmental impact refers to any change to the environment, whether adverse or beneficial, wholly or partially resulting from the organisation's environmental aspects. They are identified from a systematic evaluation or gathering of all relevant quantitative and qualitative information by experts, in consultation with informed parties, in order to make it possible for informed decision making to occur, called environmental impact assessment.

2.7.5 Risk Assessment

Definitions of terms such as risk, risk analysis, assessment and management have not been approved. In most instances the terms are used interchangeable, one notable example is that risk analysis and assessment are used interchangeably (Lingard and Rowlinson, 2005). Hence it is necessary to have a working knowledge for the electricity sector on the terminology used in the risk management field to avoid confusion where there are overlaps. Below are definitions of some of the key terms used in this study.

Risk assessment is probably the most difficult component of the risk management process and is potentially the most useful. It provides a systematic approach for the identification, management and reduction of the risk to an acceptable level. It is a critical step in risk management. If done correctly, it determines the minimum level of preparedness in order to respond effectively. It reduces the uncertainties in measuring risk and it usually involves frequency and severity.

The Health and Safety Executive (HSE), (1998) defines risk assessment as a process that identifies the hazards associated with particular activities/tasks, evaluates the effects of exposure to these hazards and implements the measure needed to control the risk of injury/ill. In addition, risk assessment has been defined as a structured process that identifies both the likelihood, and extent, of adverse consequences arising from a given activity, facility or system (Kaplan and Garrick, 1981; Gillett, 1998). For the reasons cited above, risk evaluation (assessment) could therefore be defined as the quantifying of a risk and determining its possible impact on the organisation (Valsamakis *et al.*, 2004). Assessing risks allows someone to prioritize the action to be taken to control them. In other words, risk assessment is about deciding who might be harmed and then judging how likely it is for something to go wrong, and how serious the consequences could be (Mondarres *et al.*, 1999) health to as low a level as possible.

The assessment of risks informs risk control decisions, the implementation of which is monitored and reviewed to ensure that risk is controlled and remains within tolerable limits (Lingard and Rowlinson, 2005). Australia/New Zealand Standard (2004) defines risk assessment as the process used to determine risk management priorities by evaluating and comparing the level of risk against predetermined standards, target risk levels or other criteria. The process is shown in Figure 2.2.

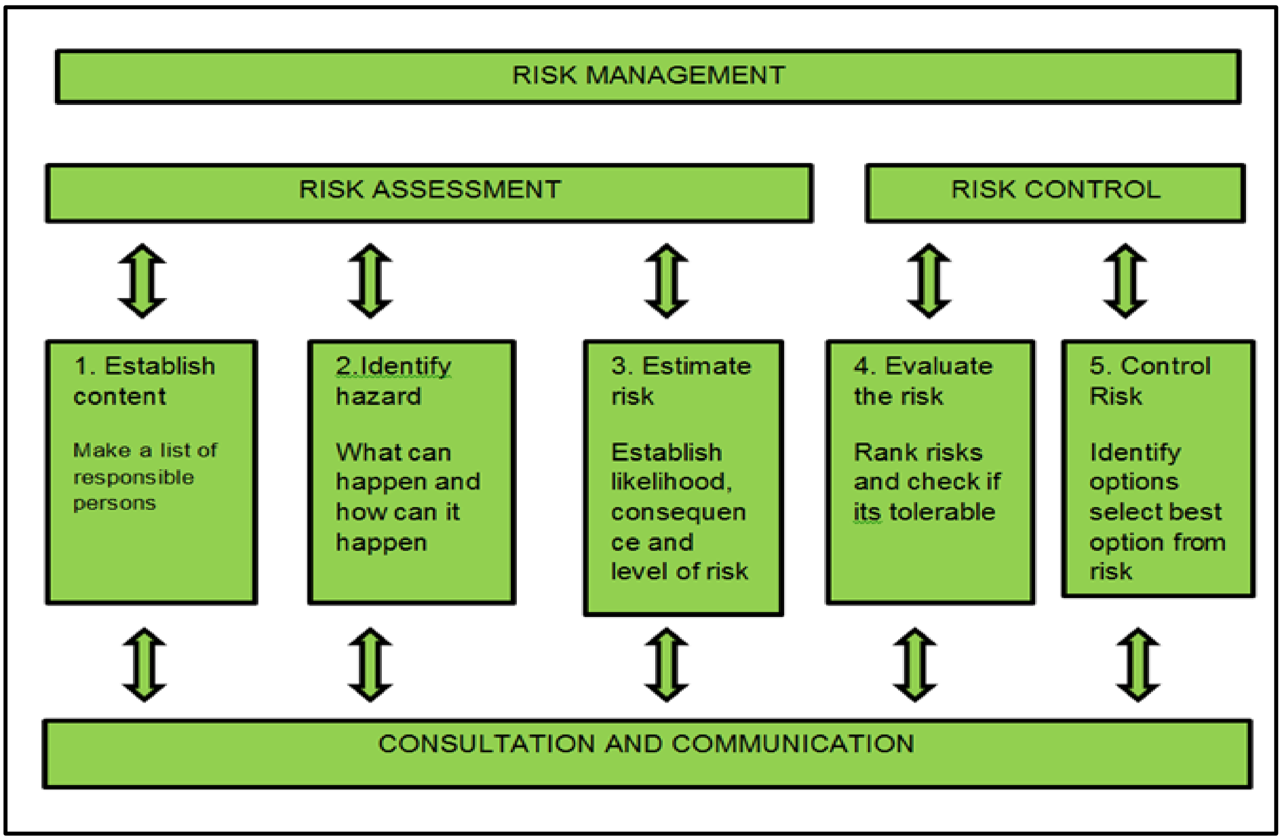


Figure 2.2: Health and safety assessment, control, and communication. Adopted from the Australian and New Zealand Standards Management (2004) and modified.

In this research risk assessment refers to the process that identifies the hazards/ aspects associated with particular activities/tasks on electricity sites, evaluates the effects and estimate hazard or aspects of exposure to these hazards.

2.7.5.1 What is Risk evaluation, Risk estimation, Mitigation and control

Risk evaluation is defined as a systematic process to judge and decide how significant an identified risk is, whether or not it is acceptable or should more be done, to what extent the risk should be reduced and what actions need to be taken to reduce the risk. Whilst risk estimation refers to the determination of the risk associated with a specific hazard in terms of the likelihood (or probability) to cause harm and the severity /extent of harm.

Risk mitigation in a risk environment, refers to the probability for limiting harmful consequences. Mitigation is known as both the most efficient conceptual framework and most effective tool at the core of risk management, which incorporates hazard identification, analysis and evaluation of the treatment of risk and risk communication (Porfiriev, 2004). Mitigating risk enables health, environment and safety issues to be considered from the point of view of institutional readiness and capacity to actively address the hazards associated with endeavours (Shepperson, 2008).

Risk control on the other hand is a technique that utilizes findings from risk assessments (identifying potential risk factors in a firm's operations, such as technical and non-technical aspects of the business, financial policies, and other policies that may impact the well-being of the firm), and implementing changes to reduce risk in these areas (Lingard and Rowlinson, 2005).

2.7.6 Environmental risk assessment

In general, the term environment covers the physical surroundings that are common to everybody including air, water, land, plants and wildlife. The environment is anything that surrounds us and can be defined as 'surroundings in which an organisation operates, including air, water, land, natural resources flora, fauna, humans and their interactions' (ISO 14001, 2004).

Fenn (2010) defines risk to the environment as those activities of an organisation that can cause some form of environmental change. Environmental risks can relate to flora and fauna; human health and wellbeing; human social and cultural welfare; earth, air and water resources; energy and climate. On the other hand, the risk to an organisation from environment related issues includes the risk of not complying with existing (or future) legislation. The associated risks include business losses an organisation may suffer as a result of poor management, such as loss of reputation, fines, costs of litigation, and from failure to secure and maintain permission for development and operational activities. Both have environmental, legal, financial, reputational and operational impacts.

Environmental risk assessment is a component of the Environmental Impact Assessment (EIA) process that facilitates identifying the significance of potential credible impacts to be able to prioritize management and mitigation measures to achieve an acceptable level of risk. It covers the risk to all ecosystems, including humans, exposed via, or impacted via, these media. Within the context of this study, environmental risk assessment would be confined to the examination of risks (environment and safety) resulting from the processes within the generation, transmission and distribution departments in the electricity company.

2.7.7 Risk management

The King II Report of 2002 defines risk management as “the identification and evaluation of actual and potential risk areas as they pertain to the company as a total entity, followed by a process of either termination, transfer, acceptance (tolerance) or mitigation of each risk.” Whilst the Australia/New Zealand Standard defines ‘risk management’ as the systematic application of management policies, procedures and practices to the tasks of identifying, analyzing, evaluating, treating and monitoring risk.

Bamber (2008), states that the vital process in health, safety and environment management is risk management, which involves the abolition or the act of reducing threat to the barest minimum of the adverse effects of the pure risks to which an organisation is exposed. The Society of Risk Managers (South Africa), however, believes that risk management is “a management function whose objective is the protection of people, assets and earnings by avoiding or minimising the potential for loss from pure risk, and the provision of funds to recover from losses that do occur”.

The definition of risk management which, however, provides the foundation for this research is that of Rejda (1992):

"… a systematic process for the identification and evaluation of pure loss exposures faced by an organisation or individual, and [for] the selection and administration of the most appropriate techniques for treating such exposures. It is a discipline that systematically identifies and analyses the various loss exposures faced by a firm or organisation, and the best methods of treating the loss exposure consistent with the organisation's goals and objectives…"

This definition is an integrated approach to risk management according to a systematic process whereby risks are identified and evaluated in order to eliminate or minimize them through the selection of appropriate techniques which will enhance the attainment of the organisation's goals and objectives.

Over the past few years there has been a marked trend towards the expansion of risk management to include the management of other risks in the organisation". Enterprise risk management requires an overview of all the aspects of an organisation with the aim of better managing the organisation's risks. Barnard (2005), states that organisation's that manage risk over the total spectrum of their business activities are more likely to achieve their objectives than organisations which focus on only one aspect of risk management.

2.8 Risk management framework and process

Risk management process is comprised of all organisational rules and procedures for the identification, analysis, assessment and control of all potential risks as well as the control and supervision of the profitability and efficiency of any measures taken. Risk management practices vary greatly and the process itself has meant different things to different people. As a result, risk management operations run the risk of being fragmented and lack central visibility and overview. In its practical implementation, a risk management system requires a clearly defined risk policy, a uniform risk terminology, a uniform risk management process, standardized tools and an appropriate risk management organisation. To this end, various risk management bodies have provided risk management frameworks, to provide the structured generic guidance, to help enterprise to enhance their risk management efforts and to better deal with risks in achieving their objectives. These standards enable organisations to compare their own risk management procedures against best practice and what is regarded as acceptable by other organisations.

Recent risk management standards and guidelines include: the Standards Australian and Standards New Zealand (2004). The International Organisation for Standardization (ISO) has recently published the ISO 31000, “Risk Management – Principles and Guidelines”. These standards are the same with regards to the generic process of risk management. Additionally the Project Management Institute (2009) provides benchmark for project management professionals for single projects. Two important risk management standards frequently used in Europe are the Committee of Sponsoring Organisations of the Treadway Commission (known as COSO), Enterprise Risk Management (ERM) an Integrated Framework and the Risk Management Standard.

2.8.1 Stages of risk assessment

Assessing risk is a step-wise process consisting of interrelated but distinct phases. Thus the context must be established first before the hazard is identified. The same is true for estimation of the risk stage, in that it cannot start until finishing identification of the hazard stage. Figure 2.3, shows five stages of risk assessment that have been identified (Bowden *et al*., 2001), which are establishing the context, identifying the risk, estimating the risk, evaluating the risk and controlling/responding to the risk. The study utilized the contents of this figure to develop the environmental risk assessment tool for this research.

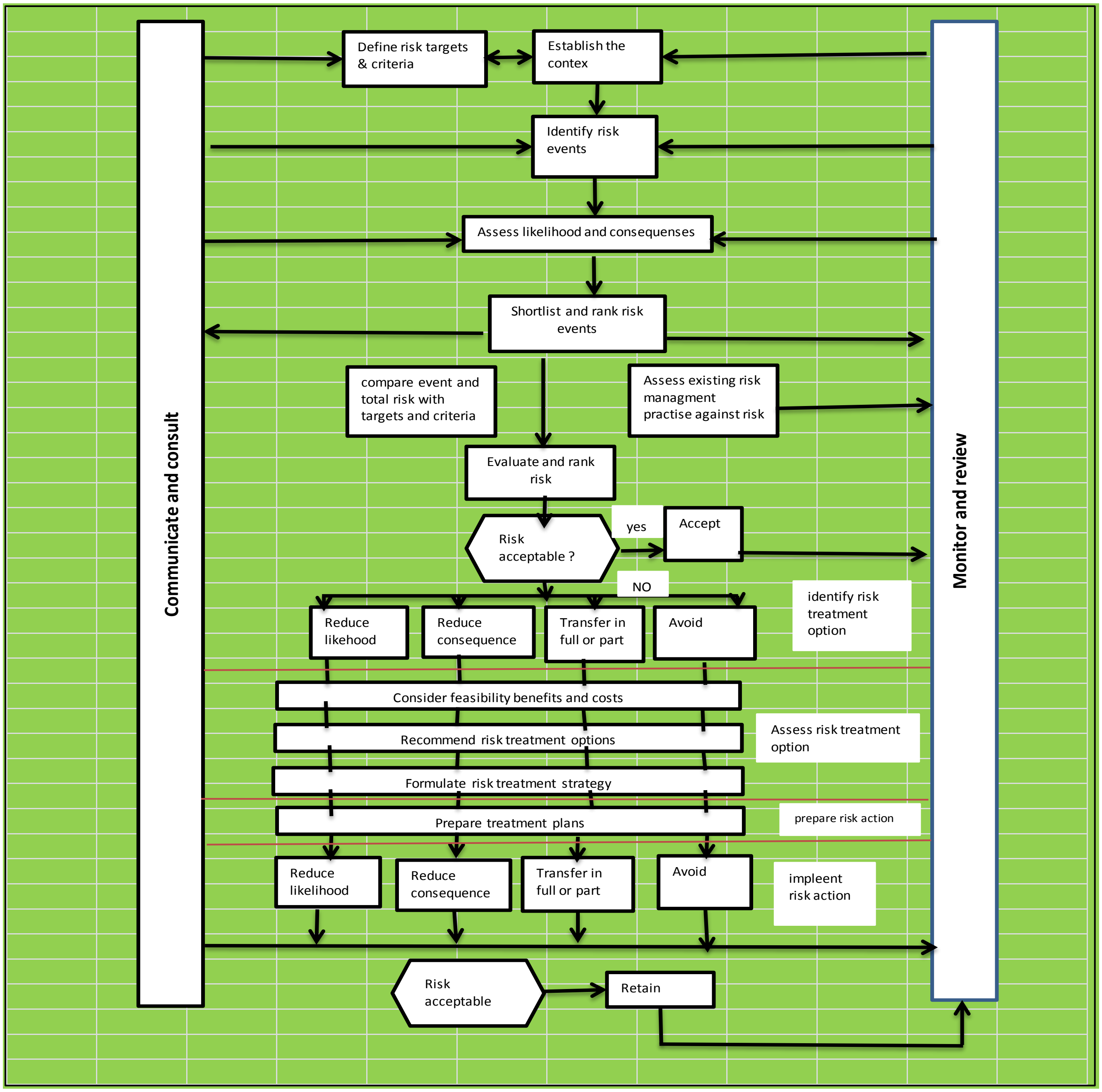


Figure 2.3: Overview of the risk management process (Bowden *et al.*, 2001)

2.8.2 Establish the context

The first stage in the process of risk assessment is to establish the context of the work or analysis of the work activities. At this stage the work activities can be analysed by making a list of the tasks that are relevant to each area of responsibility. This should include all activities that take place, the people involved in those activities, the equipment they use and the different locations they work in.

Huges and Ferret (2011) state that various types of information might be used in this initial exercise, including organisational charts and records, interviews and ‘walk-through’ surveys of the work areas involved. One of the most effective ways of ensuring that all activities are listed is to walk around the workplace and see what is going on, as it is possible that a hazard could be overlooked without a site visit.

Setting the context of a risk assessment establishes the background to the risk management process, the nature of the activities and the range of potential impacts. This process leads to identification of key stakeholders and formulation of the risk management aims and structure. The scope of the risk management process is then defined.

2.8.3 Identification of the risk

Carter and Smith, (2006) argue that risk identification is the most important stage of the risk assessment process. Identifying risk involves a systematic assessment of all risks (physical and chemical) that could affect the system (equipment or employees). In the first place these assessments involve determining the degree of risk associated with any given assignment to be performed by an employee. In addition to this, locations and processes associated with the risk have to be identified, as well as employees who are exposed, or people who might be exposed (e.g. visitors, employees or contractors) to them.

This process assists in reducing uncertainty in describing factors that contribute to accidents, injuries, illness and death. The identification process of locations and processes associated with the risk, as well as employees who are exposed, or people who might be exposed to it such as visitors, employees or contractors. Carter and Smith, (2006); Huges and Ferret (2011) have argued that hazard identification should consider hazards associated with humans, such as hazards from equipment, hazards from the work environment, for example, the condition of the site, hazards from the product such as the design and specification of the materials, hazards from the organisation such as management styles and leadership.

There are generally a number of hazard identification techniques which include brainstorming, expert opinion, structured interviews, questionnaires, checklists, historical data, previous experience, testing and modelling. It has been argued that empirical studies of risk management practice show that checklists and brainstorming are the most usable techniques for identifying hazard Simu (2009), Lyons and Skitmore (2004). Additionally multiple techniques such as physical inspection of the workplace / site, management and worker interaction, health, safety and environment audits, task / job health safety and environmental analysis, and a study of past accidents can assist in identifying areas of high risks and accident statistics (Bamber, 2008). The process of identifying risk requires a continuous and systematic approach since risks change with time.

2.8.4 Risk estimation and characterization

In this step of the process, risks are estimated from the hazards identified in the preceding stage. Due consideration is given on how many people are exposed to each hazard, and for how long. To establish the probability and severity of harm, it has been argued that the estimator should have an appreciation of the flow of the typical workday activities of that particular industry. Furthermore, knowledge of the regulations and safety standards under which the facility operates is also important, as some of the regulations provide guidelines on how to conduct the risk assessment. Moreover, experience has been mentioned as an important factor as some expert judgment may be required to estimate risk (Lingard and Rowlinson, 2005).

(Ayyubu, 2003, Lingard and Rowlinson, 2005; Huges and Ferret, 2011) concluded that the methods used to determine or estimate probability and severity, are divided into qualitative terms, quantitative terms and semi-quantitative terms. Qualitative estimate uses descriptive terms to define the likelihood and consequences of risk events. The process relies on an individual’s collective judgment in assessing the magnitude of the risks considered, which often uses risk identification terms of low, medium or high risk.

Quantitative risk estimation (QRA) uses numerical values to express both the consequences and likelihood of a given event. It involves the use of intensive mathematical equations and modelling to rank risk. This approach is an extension of the low, medium and high ranks previously used, and describes risk as the frequency of injury or death (Marhavilas and Koulouriotis, 2008, Ayyub, 2003) and Bowden *et al.,* (2001). The risk is calculated considering the potential consequences of an accident, the exposure factor and the probability factor (Marhavilas and Koulouriotis, 2008). Meanwhile, a risk matrix is also used for quantifying risk as in the case of the qualitative approach. However, only numbers are used to inform judgment on both probability and the consequences.

Qualitative estimate uses descriptive terms to define the likelihood and consequences of risk events. The process relies on an individual's collective judgment in assessing the magnitude of the risks considered, which often uses risk identification terms of low, medium or high risk characteristics.

In order to rank various risks in order of importance, a risk matrix 1 has been used. Jeong *et al.,* (2010) argued that the matrix is typically used to compare risk levels for different events and to set priorities for taking action. They further emphasize that the greater the magnitude of risk, the greater the efforts that should be made to control it and the greater the urgency to control the risk and take action. Table 2.1 below shows risk matrix table for qualitative approach and risk rating.

Table 2.1: Risk matrix table for qualitative approach and risk rating (Adopted from Phoya 2012 and modified)

			1 Insignificant impact	2 Minor Impact to small population	3 Moderate to minor impact to large population	4 Impact to small population	5 Major impact to larger population
Likelihood	1	Rare	Low	Low	Moderate	High	High
	2	Unlikely	Low	Low	Moderate	High	Very High
	3	Moderate /possible	Low	Moderate	High	Very High	Very High
	4	Likely	Moderate	High	High	Very High	Extreme
	5	Almost certain	Moderate	High	Very High	Extreme	Extreme

Phoya in a study done in 2012 presented a simple ranking mechanism of a matrix, indicating different levels of risks. The study used a 5x5 risk matrix and a semi quantitative method. The negligible injury was rated as level 1 whilst the minor injury was rated as level 2. Level 3 was assigned for moderate injury whilst level 4 was assigned for major injury. Level 5 was assigned for fatalities. Similarly, likelihoods were assigned as follows: very likely as level A, likely as level B, possible as level C, unlikely as level D, or rare as level E. In addition Table 2.1, indicates that there are 25 potential risk combinations and the risk outcomes can be divided into four risk levels (ratings) namely, Extreme, High, Moderate and Low. This rating implies that the extreme situation indicates there are fatal consequences which should be tackled first while low rating indicates there is negligible injury which requires first aid (Phoya, 2012).

The second classification of risks is shown in Table 2.2 and is made on the base of risk acceptance. Generally there are four categories in this meaning: “unacceptable”, “unwanted”, “acceptable” and “negligible”. Finally the risk assessment values are populated in a register with items of “frequency of occurrence”, “severity of consequence” in descriptive and quantitative values. Hence it is decided about the risk whether it is acceptable or not.

Table 2.2: Matrix for quantitative approach for estimating and rating risks. (Adopted from Phoya, 2012)

	Hazard probability ratings					
Severity of consequences ratings	**1**	**2**	**3**	**4**	**5**	**6**
1	1	2	3	4	5	6
2	2	4	6	8	10	12
3	3	6	9	12	15	18
4	4	8	12	16	20	24
5	5	10	15	20	25	30
6	6	12	18	24	30	36

Legend

(red)	Unacceptable	18 to 36
(orange)	Undesirable	10 to 16
(yellow)	Acceptable with controls	5 to 9
(blue)	acceptable with controls	1 to 4

Risk assessment process is repeated and risk levels are estimated once more by the same method of analysis for the conditions after mitigation and then it is checked whether the risk level is reduced to acceptable level or not. Where the decision at the end of the risk assessment is in the way of that new or improved controls are required to bring risks to the acceptable level, a further process of "determining controls" should be carried out. This is the most important leg of process subsequent to hazard identification and risk assessment processes, because the final aim of all the assessments carried out by now, and of course, to provide a safe working workplace and minimize the risks of persons.

Phoya (2012), however, states that it has been observed that the qualitative approach has some limitations, such as it is not easy to incorporate the effects of risk reduction measures within the risk matrix, and neither method is easy to use to assess cumulative hazards, in particular at facilities where a large number of hazards exist.

2.8.4.1 Risk evaluation

Risk evaluation involves an analysis of information derived from the identification process so that priorities may be assigned in respect of high risk activities. According to Barnard (2005) when evaluating risks, management should pose the following pertinent questions:

- How much danger does the activity constitute?

- How soon will the danger eventuate?
- At what frequency will it take place?
- Who is exposed?
- What are the consequences of the activity?

The risk evaluation process can be used to identify and prioritize the risk that certain activities might expose individuals who work on a particular activity. The purpose of risk evaluations is to decide whether or not a risk is tolerable (Lingard and Rowlinson, 2005, Huges and Ferret, 2011). If the risk is regarded as acceptable as indicated in Table 2.2, it may be enough to control the risk instead of reducing it. However, if the risk is regarded as unacceptable then different risk reduction options have to be explored and compared so that the best risk reduction option can be identified. The evaluating stage of the risk-assessment process involves assessing the team making decisions on the most appropriate risk control strategies.

Once a level has been established for the risk estimated, the levels are compared with previously established risk criteria to create a prioritized list of risks to be controlled. It may become an important task to identify and select the relevant specific risk criteria for specific estimated risks in a specific country and/or industry. Selecting risk criteria may also depend on the results of the risk analysis and how risks are estimated. There are different principles described in literature for evaluating risk and it is important that the principle used is openly communicated and accepted by the stakeholders involved. The evaluation principles form the basis for defining risk tolerability (Barnard, 2005).

2.8.5 Risk control

A risk control measure refers to any part of a facility, including any system, procedure, process or device that is intended to eliminate hazards, prevent hazardous incidents from occurring or reduce the severity of consequences of any incident that does occur (Lingard and Rowlinson, 2005). Controlling risk takes the form of implementing managerial, procedural and/or engineering controls that will effectively reduce or eliminate the risk. The implemented control measures may be proactive, in that they eliminate, prevent or reduce the likelihood of incidents, or they may be reactive, in that they reduce the consequences of incidents. The control measures in occupational health and safety context, risk control is categorised according to the hierarchy in Figure 2.4, often simply called the “risk control hierarchy.” This hierarchy helps people to decide on which risk control to implement. Risk control options at the top of the hierarchy are preferred more than those at the bottom of the hierarchy. The preferred options are the most effective means of controlling risks because they are much less reliant on people to do something and they can protect a larger number of people.

The process does not end there because these controls have to be monitored to determine both their initial and continuing effectiveness. Legal compliance, as well as International Standard Organisation (ISO) systems audits — such as the ISO 14001 (2004), Environment Management System, ISO 9001 (2008), Quality Management system, and OHSAS 18001 (2007), Occupational Health and Safety third party audits — will ensure the effectiveness of managerial or procedural and engineering controls to a certain degree, depending on the extent to which the system has been entrenched.

The risk control hierarchy consists of five stages of control risk as portrayed in Figure 2.4.

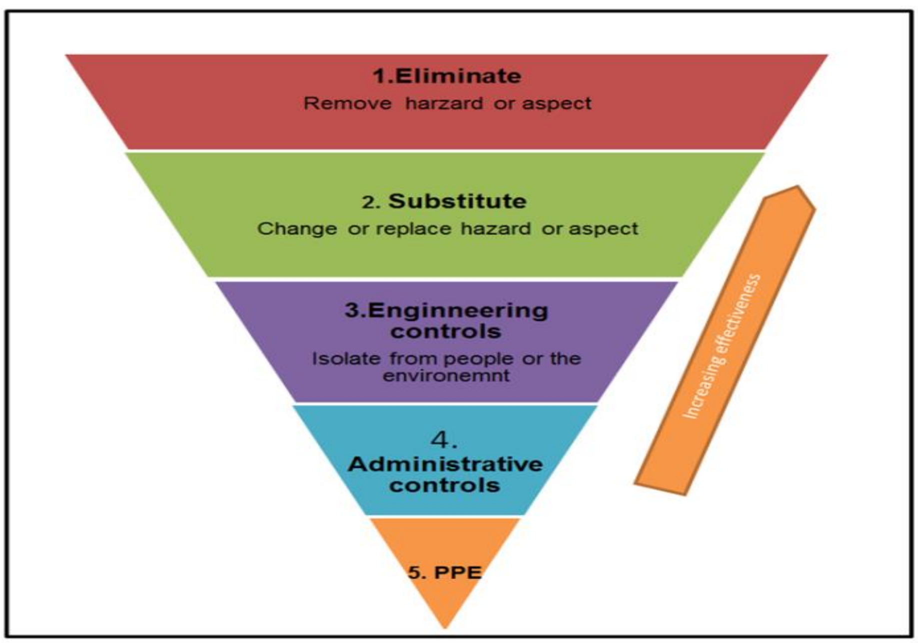


Figure 2.4: Risk Control Hierarchy

The first stage is elimination of the hazard. At this stage hazard is totally eliminated. However, it is difficult to eliminate all unsafe conditions, and therefore elimination is not always possible (Marhavilas and Koulouriotis, 2008). The second stage is reducing the hazard or making a substitution. At this stage the risk is controlled by reducing it or substituting it with lesser hazards. The third stage is isolation where risks are combated at source and access to the hazard is prevented.

The fourth stage is introducing a safe system of work. This stage uses information such as written procedures and safe systems of work, instruction, training and supervision. It ensures that employees understand what they must do and when, how they must do it and what activities are prohibited. These are work practices that alter the way the work is done in order to reduce the risk of hazardous tasks. Providing personal protective equipment (PPE) is the last stage in the risk control hierarchy. It has been argued that PPE should be opted only as the last resort and only after all other measures have been implemented (HSE, 1998; Huges and Ferret, 2011).

The determination of controls process for instance, take “electrical works” as “process (hazard)”, then “mitigation” would be preparing “electrical safety procedure”, and then “proposed actions” in prioritized manner would be 1.Implement procedure, 2.Supervision, 3.Test/inspection of equipment 4.Regular maintenance, 5.Certified electrician, 6.Awareness. Finally by “in charge” topic “mitigation” and “proposed actions” are addressed (Ceyhan, 2012).

At the end of hazard identification, risk assessment and determining controls processes, all of the results obtained for each process are documented in comprehensive “risk register” tables as a total. Those “risk registers” are the fundamental documents of overall management systems and they are reviewed and continually improved throughout occupational health and safety management (Ceyhan, 2012).

Consultation and communication is both a key component of the risk management process and a major beneficial side effect. Risk management decision makers have both legal and moral responsibility to provide information to people exposed to risks. Successful risk management relies on achieving a high level of creative input and involving all parties in achieving a successful outcome of the project or business process being addressed.

One important part of risk communication is how to present the risk information. Slovic (2001) pointed out that different ways of presenting the same risk information can lead to different evaluations and decisions, even though they are logically equivalent. Risk research has shown that the basic understanding of risks differs within societies. According to Bohrmann (2000), effective communication depends greatly on the characteristics of the messages distributed, the conveying authority, the receiving audiences and the context in which the communication process occurs.

On construction sites including electricity facilities, different tools can be used to disseminate information, such as Safe and healthy construction sites induction training, handbooks, team briefings, toolbox talks, supervision meetings or other management meetings, specific or general instruction or training sessions and hands-on training (HSE, 2010). People in interaction with each other tend to communicate in different ways, either formally or informally (Bohrnmann, 2000).

Constant monitoring and evaluation of risks are the driving forces of a feedback system of control. This process must be repeated to ensure whether all the hazards that were identified initially are, in fact, still present or whether they have been successfully dealt with (checklists, audits and so on are used for this purpose).

2.9 Risk assessment models

Several risk assessment models are used in different industries. Some of these models as listed in Table 2.3 and Figure 2.5 are considered the most common methods used in risk analysis.

Table 2.3: Risk Assessment Models. International Organization of standardization by the International Electrotechnical Commission (ISO IEC)

Model	**Description**
Event Tree Analysis	A risk identification and frequency analysis technique which employs inductive reasoning to translate different initiating events into possible outcomes
Fault Modes and Effects Analysis ;Fault Modes, Effect and Criticality Analysis	A fundamental risk identification and frequency analysis technique which analyses all the fault modes of a given equipment item for their effects both on other components and the system
Fault Tree Analysis	A risk identification and frequency analysis technique, which starts with the undesired event and determines all the ways in which it could occur. These are displayed graphically
Hazard and Operability Study	A fundamental risk identification technique which systematically evaluates each part of the system to see how deviations from the design intent can occur and whether they can cause problems
Human Reliability Analysis	A frequency analysis technique which deals with the impact of people on system performance and evaluates the influence of human errors on reliability
Monte-Carlo Simulation	A frequency analysis technique which uses a model of the system and other simulation techniques to valuate variations in input conditions and assumptions
Hazard Indices	A risk assessment technique which can be used to rank different system options and identify the options with the least risk
Review of Historical Data	A risk assessment identification technique that can be used to identify potential problem areas and also to provide an input into frequency analysis based on accident and reliability data

Table 2.4: Comparison of some examples of risk assessment and methodologies. (OHSAS 18002, 2008).

Tool	**Strengths**	**Weakness**
Checklist / questioners	• Easy to use • Use can prevent missing something in initial	• Often limited to Yes/ no structures • Only as good as the checklist used –it might not take into account unique situations
Risk Matrices	• Relatively easy to use • Provides visual representation • Does not require use of numbers	• Only 2 dimensional – cannot take into account multiple factors impacting risk • Predetermined answer might not be appropriate to the situation

Tool	Strengths	Weakness
Ranking /voting tables	• Relatively easy to use • Good for capturing expert opinion • Allows for consideration of multiple risk factors (e.g. severity, probability, detectability, data uncertainty)	• Requires use of numbers • If the quality of the data is not good, results will be poor • Can result in comparison of incomparable risks
Failure modes and effects analyses (FMEA)	• Good for detailed analysis of processes	• Needs expertise to use • Needs numerical data to input into analysis • Takes resources (time and money) • Better for risks associated with equipment than those associated with human factors
Exposure assessment strategy	• Good for analysis of data associated with hazardous materials and environments	• Need expertise to use • Needs numerical data to input
Computer modelling	• If relevant and sufficient data are available computer	• Significant time and money needed to develop and validate • Potential for over reliance on the results , without questioning their validity
Pareto analysis	• A simple tequnique that can assist	• Only useful for comparing similar items i.e. unidimensional

Information on these methods of analysis has been derived from the OHSAS 18001 International Standard on Occupational Health and Safety.

2.10 Sources of risk in the electricity sector

Risky events can be caused by external factors (economic, environmental, social, political and technological aspects) or internal factors (infrastructure, human resources, process and technology used by a company) (COSO, 2004). According to Tchankova (2002) the sources of risk can be categorized depending on the environment in which they arise, as follows; physical environment, social environment, political environment, operational environment, economic environment, legal environment and cognitive environment. In a survey presented in (Sand *et al*., 2007), different risk consequence categories for electricity distribution companies are grouped into the following: Economic risk, Safety risk, Environmental risk, Quality of supply risk, Reputational risk, Vulnerability risk, and Regulatory risk.

The above-mentioned sources of risk are considered highly relevant when assessing the activities undertaken in electricity generation, transmission and distribution. For the purposes of this research, the physical, social, legal and operational risk will be discussed in relation to the electricity industry in Swaziland.

2.10.1 Physical environment

The physical environment is an important source of risk. The environmental influence of the electricity sector on the people, and people's influence on the environment, is important aspects of this source of risk.

2.10.2 Social environment

Changes in people's values, human behavior, and the state of social structures are further sources of risk. Civil unrest, social riots, and strikes are events that exemplify the importance of the social environment as a source of risk.

2.10.3 Operational risks in the electricity sector

Electricity and the inherent risks associated with its use in the built environment have long since been a priority for the electrical services industry and also the general public who must live and work in this environment. However, the inherent risks associated with its use will always exist and will continue to be a priority for the electrical services industry. The following operational risks are common to the electricity industry, and should be identified by means of the risk assessment process.

1. Electrical hazards

The principal electrical hazard to humans is the potential of electrocution. The major electrical hazard to property is from electrical faults attributable to faulty installations which may cause short circuits and arcing, in turn leading to large releases of energy and damage to equipment. Table 2.6 indicates the electrical safety hazards associated with various industry.

2. Legal environment

The Electricity industry in Swaziland is well regulated. Specific examples include the Swaziland Occupational Health and Safety Act 2001 and the Swaziland Environmental Management Act 2002 and the Swaziland Electricity Act 1968. The legal environment is a further factor which creates risk and uncertainty in business. While this is valid for all countries, it has become increasingly important in Swaziland over the past ten years. The legal system creates risk because of the disparity between existing and new laws pertaining to the environment.

3. Cognitive environment

The risk manager's ability to reveal, understand and assess risk can, for psychological reasons, never be perfect. It is an established fact that the differences between the perceptions of different people and the objective reality are an important source of risk in any organisation. The cognitive environment therefore constitutes a major challenge for every risk manager.

Table 2.5 and Table 2.6 in the next sections present hazards associated with the electricity industry and any construction industry. .

Table 2.5: Potential construction hazards adopted from Reese *et a*l., 2007.

Potential hazards	
Premature explosions	Hand arm vibration
Roll over	Moving of heavy machinery
Electrocution	Concrete handling
Mounting and dismounting heavy equipment	Working with sharp object
Dust generation	Wet/ slippery surfaces

Table 2.6: The Biggest electrical safety hazards per respondent (% respondents) from various industries (Tulonen, 2010).

Risk		Energy (%) (n=143)	Industry (%) (n=218)	Real estate (%) (n=131)	All (%) (n=541)
1.	Hurry	54	66	69	64
2.	Working alone	35	33	24	32
3.	Attitudes towards safety	28	32	31	30
4.	Working conditions	36	24	26	27
5.	Getting used to the risk	16	22	19	19
6.	Conscious risk taking acts	17	17	20	18
7.	Unforeseeable changes in work assignment abnormal situations disturbances	20	17	9	15
8.	Objects/ substances(falling, striking, getting entangled, moving objects)	18	13	15	15
9.	Work paid by the job as opposed to working hourly	14	10	9	11
10.	Equipment, instrumentation, machinery	8	11	20	11
11.	Work posture	17	10	9	11
12.	Over emphasis on financial factors	9	10	13	11
13.	Amount of works	10	8	15	11
14.	Own customary working procedures	10	7	11	10
15.	Professional skills	6	12	11	10
16.	Inadequate documentation	2	12	15	10
17.	Working plan, organisation of work distribution	10	7	11	10
18.	Continuous vigilance, slacken attention	10	9	12	10
19.	Over estimating own abilities	5	10	10	8
20.	Identification of risks at work	5	11	6	8
21.	Occupational instruction and guidance, orientation	6	11	2	7
22.	Flow of information	8	9	5	7
23.	Subcontracting, outsourcing	6	7	4	6
24.	Increase, development, diversification of modern tech and automation	4	7	5	6
25	Interruptions at work	1	6	9	6
26	Traffic	19	1	1	6
27	Monotonous work	3	5	8	5
28	Protective equipment, safeguards				
29	Too high demands and aims	9	3	5	5
30	Diversity of work assignment	1	5	6	4
31	Level of maintenance	8	3	5	4

Risk		Energy (%) (n=143)	Industry (%) (n=218)	Real estate (%) (n=131)	All (%) (n=541)
32	Performance pressure	3	6	5	4
33	Private life situations	3	4	5	4
34	Changing work environment	4	4	2	3
35	Management	2	3	2	3
36	Continuous organisational changes , uncertainty of work continuity	4	2	3	3
37	Work atmosphere	4	2	2	3
38	Instructions, directions, rules	5	2	1	3
39	Electrical education	2	2	2	2
40	Working instruction	2	2	2	2
41	Cooperation	1	1	2	1
42	Chemical , mold, virus , bacteria	0	2	2	1
43	Organisation's workings	0	0	2	1
44.	Vandalism	1	0	0	1
45.	Threat of violence	1	0	0	0

Pattnaik (2009), states that the electricity industry is a hazardous operation and consists of considerable environmental, health and safety risk to employees and the public. Environmental and safety risk assessment is the systematic identification of potential hazards and aspects in workplace as a first step to controlling the possible risk involved. Unsafe conditions in electricity operations have a potential to cause a number of accidents and cause loss and injury to human lives, damage to property and the environment. Hazards and aspects cannot be completely eliminated therefore there is a need to define and assign a risk level possible to be presented in either a quantitative or qualitative approach. Table 2.7 below, shows the consolidated environmental risk register for utilities in the Southern African Power pool obtained from Environmental Subcommittee reports (2016).

Table 2.7: Southern African Power Pool Environment risk registers (Environmental subcommittee, 2016).

Reference	Risk Description			Inherent Risk	Current Controls	Probability	Severity	Risk Rating	Additional Measures	Risk Owner	Implementer
	Risk Event/ Aspect	Cause	Impact								
1.1	Hazardous waste storage (used oil, ash, asbestos, transformers, used, batteries etc.)	Improper storage facilities	Land, water and Air pollution	Very High	-Hazardous waste stored in bunded areas, on impervious concrete surfaces. -Restricted access to storage sites	4	5	20	-Monitoring Integrity of bund walls -Adequate supervision -Store used oil in approved containers -Build bunded and oil drainage structures -Undertake, implement and monitor controls	SAPP	Utilities
1.2	Improper disposal of hazardous waste (HW)	Lack of disposal facilities Lack of recycling facilities	-Land, water and -Air pollution -Land Pollution -Water Pollution	Very High	-Disposal through licensed third parties	3	5	15	-Waste Management disposal policies and procedures -Dispose all HW in line with ratified conventions and National laws -Undertake, implement and monitor controls -Continue disposal through licensed parties -Recycle where appropriate	SAPP	Utilities

1.3	Improper Spillage Management	-Inadequate competence -Non-availability of cleanup kits	-Air, Land and water pollution -Penalties by Department of Environment	Very High	-Training of handlers on competency - Spill kit availability	4	5	20	-Development implementation and monitoring of spillage management procedures; Procurement of spillage kits -Capacity building on use of spillage kits -Compliance to the management plans	SAPP	Utilities
1.4	Wayleave encroachment (building, flora and fauna)	-Lack of awareness by the general public - Uprooting of vegetation Lack of knowledge of requirement -Lack of knowledge on the wayleave boundaries	-Injury to the public -Invasive species near electricity networks substations - Loss of Biodiversity (trees) under power lines) - Improper vegetation clearances (cutting beyond servitudes)	High	-Public sensitization & Stakeholder engagement and management plan monitoring	8	6	48	-Install concrete signage -Public awareness -Continued monitoring -Use of environmentally controls -Undertake, implement and monitor management plans	SAPP	Utilities
1.5	Wild/veldt fires	-Lack of awareness by the general public -Not clearing the wayleave	-Disruption of power transmission -Air pollution	High	-Public sensitization & Stakeholder engagement	3	6	18	-Public awareness -Stakeholder engagement -Development and monitoring of the environmental emergency preparedness plans	SAPP	Utilities
1.6	Bees and Birds nesting on the lines /substation	-Nature	-Disruption of power transmission -Loss of fauna and electrocution of birds	Moderate	-Line patrols -Bird nest migrations	3	6	18	-Bee and Birds cropping -Installation of bird flappers -Network designs to not support bird nesting	SAPP	Utilities

1.7	Explosion resulting from lightning strikes on the infrastructure causing oil spillage	-Lack of lighting protection. -lack of earthing -Lack of capacity in managing spillages	Land and water pollution	Moderate	- Lighting arrestors - Earthing -Provision of spillage kits	5	8	40	- Monitoring integrity of lighting arrestors and earthing -Possession of spillage kits -Development, implementation and monitoring of spillage management procedures	SAPP	Utilities
1.8	Carbon emission	Combustion of fossil fuels	-Air Pollution (Climate change)	Extremely High	-Compliance to National standards, Conventions and Climate change adaptation strategies	6	6	36	-Development and monitoring of the utilities climate change policies	SAPP	Utilities
1.9	Environmental non-compliances	Failure to conduct and/or monitor EIAs	-Non acceptance of projects by stakeholder -Challenges with acquisition of wayleaves and servitudes -Rejection of projects by NGOs -Withdrawal of finances -Legal penalties	Very High	Environmental Policy and EIA procedure	4	6	24	-Compliance to National laws and International Conventions	SAPP	Utilities
1.10	Insufficient coordination in SAPP projects	-Lack of stakeholder engagement	-Breach in trans-boundary environment legislation -Delay in completion of projects and Environmental penalties	Very High	-Liaison between utilities Linkage of the SAPP coordination centre	6	6	36	-Involvement of the ESC representatives in trans-boundary projects	SAPP	Utilities

1.11	Lack of Emergency preparedness plans	-Lack of competence -Lack of funds	Land, water and Air pollution	Very High	-Implement and monitor management plans	3	8	24	-Refresher training - Development of SAPP Environmental Emergency preparedness plans	SAPP	Utilities
1.12	Emission of SF_6 from switch gear equipment	-Lack of maintenance -Lack of capacity	Air pollution	High	-Monitoring equipment for SF_6 leaks -Monitoring of ESMPs	3	7	21	-Capacity building -Continued implementation of ESMPs	SAPP	Utilities
1.13	Lack of budget for environment aspects for project	-Lack of prioritizing environment	-Failure to implement environment projects and compliance to legislation	Very High	Budgets include environment aspects	3	4	12	-Prioritization of environmental issues	SAPP	Utilities
1.14	Insufficient resource conservation (water, electricity, fuels)	-Lack of monitoring -Lack of understanding	-Depletion of resources	Very High	Monitoring of resource consumption (Maximum demand)	5	7	35	-Installation of water flow meters at the raw water intake point	SAPP	Utilities
1.15	Inadequate waste management	-Lack of awareness -Lack of resources -non adherence to environment plans	-Land, water and Air pollution - Rodents tripping stations	Very High	Waste management plan in place	3	7	21	-Monitoring -Review of the Waste management plans	SAPP	Utilities
1.16	Storage and Disposal of used tyre	Maintenance of vehicles	-Land take	High	-Sold to employees -recycles	2	3	6	-Engagement of recyclers	SAPP	Utilities
1.17	Lack of inclusion of environmental aspects in procurement process	-Lack of awareness	-Air, land and water pollution -Delayed projects implementation	High	-Green procurement procedures	3	7	21	-Awareness raising and implementation of the IFC principles	SAPP	Utilities
1.18	Soil erosion threatening lines	-Run-off -Poor soil structure	-Fallen lines -financial loss	High	-Projects planning	5	8	40	-Undertaking of ESIAs -Monitoring of ESMPs	SAPP	Utilities

1.19	Unreliable Clean development mechanism market (CDM)	-Decline in the CDM market	-Lack of financing for the CDM projects -Decline in the implementation of renewable energy projects	Very High	-Continue to implement the already registered CDM projects	6	8	48	-Implement of renewable energy projects	SAPP	Utilities

2.11 Importance of risk assessment

All over the world electricity poses a constant hazard to those performing electrical work. Together with handling cost and performance, the management of risk is therefore a key issue for electricity distribution companies, and there is now an increased awareness about taking risk assessment into account in the decision making context (Sinclair, 2009). The Swaziland Occupational Health and Safety Act (2001), requires employers to ensure that, so far as is reasonably practicable, their employees, visitors and others affected are not exposed to risks to their health or safety. In this respect, the purpose of a risk assessment is to help the employers to ensure that everything that is reasonably practicable has been done to address health and safety risks. Secondly the Swaziland Environmental Management Act (2002), requires that when establishing or operating any development there is need to identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage, the risks and consequences and alternatives and options for mitigation of activities, with a view to minimizing negative impacts, maximizing benefits, and promoting compliance with the principles of environmental management.

3 CHAPTER 3: APPLICATION OF ISO 14001 AND OHSAS 18001 AT SEC

3.1 Introduction

This section presents a general outlook and summaries about the operational principles of Occupational Health and Safety Assessment Series (OHSAS 18001, 2007) and Environmental Management System (EMS) (ISO 14001, 2004) standards which were used to develop the environmental risk assessment in the electricity sector. The Swaziland Electricity Company (SEC) which is the case study area, within its strategic objectives sought to identify and manage the environmental, safety and health risks by implementing the above mentioned international standards. The two standards were found to have risk analysis and reduction as their main objective. ISO 14001 (2004) was used to identify and minimize environmental impacts or environmental risk whilst OHSAS 18001 (2007) was used to identify and reduce health and safety risks associated within the company processes. Hence, the implementation of the two standards by the company, assisted in achieving the main objectives of this study, which are to develop an environmental risk assessment and develop an innovative assessment tool in the electricity sector.

The scope of the environmental risk assessment was derived from clause 4.3.1 of the ISO 14001 (2004) and OHSAS 18001 (2007). This clause in both standards provides the important foundation for implementing the two systems in the organisation and without it the overall systems would surely fail. It has three aspects that had to be considered in this study namely;

a. Identification of environmental aspects or hazards associated with the company's activities.
b. Risk assessment, a process of evaluating the risk arising from the hazard and aspects.
c. Determination of applicable controls to eliminate or reduce risk to an acceptable level. Measures are based on the hierarchy of control measures.

3.2 Application of ISO 14001 EMS and OHSAS 18001

The application of the ISO14001 (2004) and OHSAS18001 (2007) is discussed in detail in the next sections.

3.2.1 ISO 14001 EMS of 2004

Organisations worldwide operate within a context where legislation plays a critical role, where the development of international policies presses for environmental protection, and where a growing concern begins to arise in relation to environmental issues and sustainable development by various interested and affected parties (ISO 14001, 2004).

According to Quazia *et al*., (2001) rigorous control of the impacts generated by the enterprise’s operations with the internal and external environment, are required to ensure environmental quality, elimination of risks associated with the disposal of wastes in neighbouring areas, disposal of contaminated effluents, noise propagation, among other issues. Environmental management systems based on ISO 14001 (2004) proved to be an interesting alternative to achieve these aforementioned objectives. ISO 14001 (2004) has a framework that guides the enterprise in understanding and structuring an appropriate management system. It permits the development of some environmental analysis tools and helps define the product life cycle.

ISO 14001 (2004), as an International Standard, specifies requirements for an environmental management system to enable an organisation to develop and implement a policy and objectives. This takes into account legal requirements and other requirements to which the organisation subscribes, and information about significant environmental aspects. It applies to those environmental aspects that the organisation identifies as those which it can control, and those which it can influence. The system helps organisations to comply with environment legislation and other requirements, ensure their sustainability and improve environmental performance.

3.2.2 OHSAS 18001 of 2007

Worldwide, many organisations are currently implementing the Occupational Health and Safety Assessment Series as part of their risk management strategy and also to fulfill legislative requirements and protect their employees. OHSAS 18001 (2007) provides a framework that allows organisations to constantly identify and control their health and safety risks, reduce the potential for accidents, aid legislative compliance and improve overall occupational health and safety performance.

Additionally, OHSAS 18001 (2007) was created via the concerted and combined effort from a number of the world's leading national standards bodies, certification bodies, and specialist consultancy groups. It was developed to help organisations meet their health and safety obligations in an efficient and effective manner. It helps in a variety of respects; to minimize risks to employees, improve an existing OHS management system, demonstrate diligence and gain assurance. The aim of OHSAS 18001 (2007) is to manage a healthy workplace with a safe working environment by removing or minimizing the aforesaid risks in the light of the law, legislation, principles and regulations about workplace health and safety.

The above mentioned two systems OHSAS 18001 (2007) and ISO 14001 (2004) have similarities in their structure and requirements. These include the development of procedures for understanding risks/hazards and aspects/impacts, setting objectives and targets, establishing programs to achieve those identified objectives and targets, and reviewing performance against the identified objectives and targets. OHSAS 18001 (2007) and ISO 14001 (2004) are that part of the overall management system which include; the organisational structure, responsibilities, practice, procedures, processes and resources for determining and implementing the environmental or occupational health and safety policy. When an environmental or occupational health and safety policy is adopted, the environmental or occupational health and safety management program should follow a continuous improvement cycle. Hence, the two systems are aligned based on continual improvement and regulatory compliance.

3.2.3 Implementation of OHSAS 18001 and ISO 14001 within SEC

The implementation of OHSAS 18001 (2007) and ISO 14001 (2004) within SEC, addressed the following elements of the standards;

- Planning for hazard/ aspect identification and risk control/impact management
- OHSAS /EMS management programme
- Structure and responsibility
- Training and awareness and competence
- Consultation and communication
- Operational control
- Emergency preparedness and response and performance measuring, monitoring and improvement

The implementation of OHSAS 18001 (2007) and ISO14001 (2004) suggested the use of the approach known as Plan-Do-Check-Act (PDCA Cycle). The PDCA cycle demanded establishing objectives and processes, implementing the processes, monitoring and measuring processes and then taking action.

The implementation of the two standards as seen in Figure 3.1 is almost identical except that occupational health and safety is substituted by environmental. The main significant difference is that ISO 14001 (2004) is built around significant environmental aspects and impacts of an organisation whilst OHSAS 18001 (2007) is a result of health and safety risk assessment (Labodova, 2004).

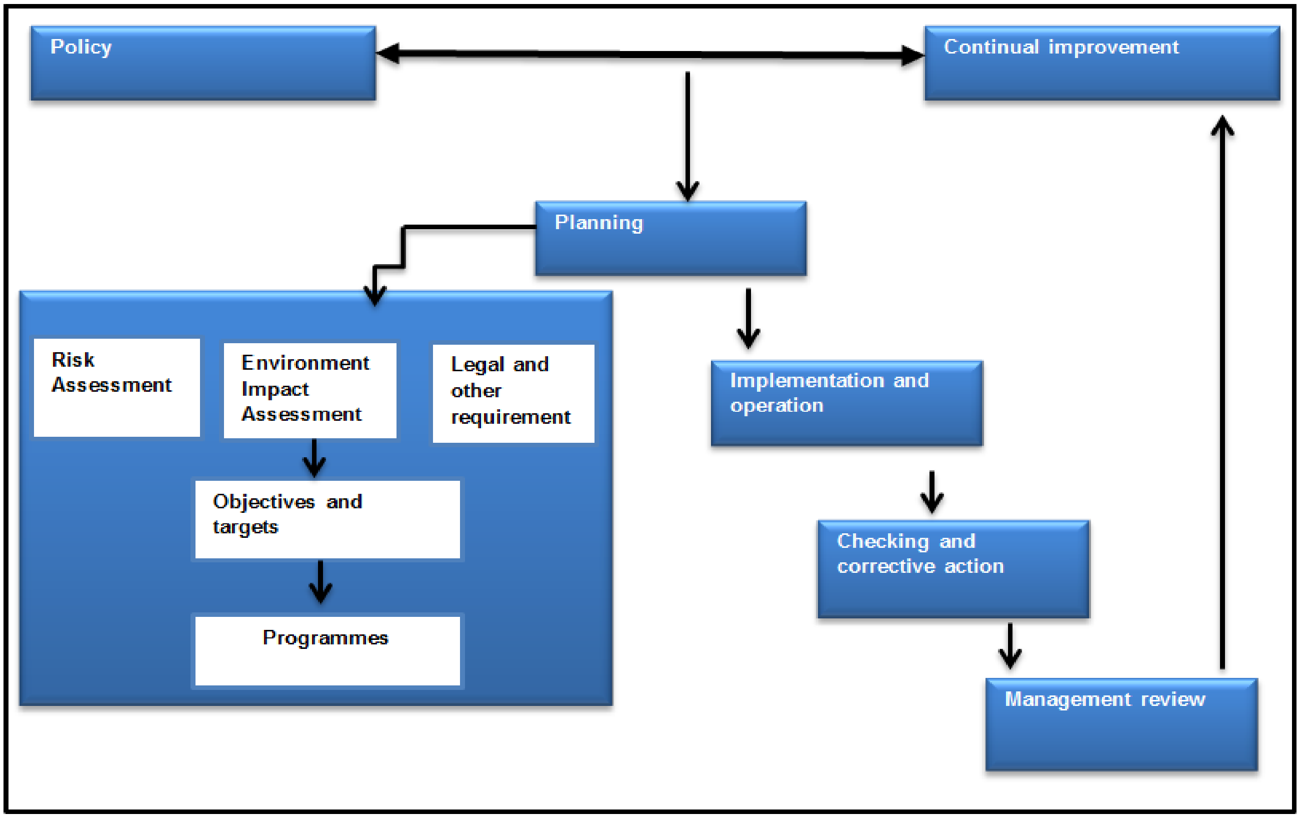


Figure 3.1: Key components of ISO 14001 (2004) and OHSAS 18001 (2007)

The following key attributes were critical in formulating risk assessments in line with the premises of the OHSAS 18001 (2007) and ISO 14001 (2004) management systems.

3.2.3.1 Policy

Two separate policies for OHSAS 18001 (2007) and ISO 14001 (2004) were developed by SEC senior management. This demonstrated their commitment towards protection of health and safety of its employees, by reducing ill-health and accidents as well as environmental impacts resulting from the company's activity. The policies indicated that the organisation was fulfilling the legal and other applicable requirements. The policies were relevant to scope of organisational activities and properly documented, communicated, signed with date and available to all the concerned parties at any time. The policies included as a minimum, the commitment of the organisation about the items below:

1) Preventing injury and ill health,

2) Complying with applicable legal requirements relevant occupational health and safety (OHS) and environmental management national laws and regulations as well as with the other requirements to which the organisation subscribes,

3) Pollution prevention

4) Continually improving OHS and environmental management and performance.

3.2.3.2 Planning

The hazards, aspect and risks identification and their assessment, thereof were defined in planning phase. It was performed on continuous basis to identify, prevent, control and reduce risks in the future before it happened. It considered all the activities of the organisation, behaviour of people linked directly or indirectly to those activities and the effect of equipment being used. Reduction of hazards, aspects and risk was performed by eliminating, controlling or replacing of the main cause.

According to Ceyhan (2012), hazard and aspect identification mainly requires an exhaustive work flow and activity analysis to reach the hazards which may possibly arise during execution of any construction work. The process considers any kind of work or activity, both routine and non-routine activities, and situations and sources. For instance, the activities such as equipment cleaning or non-scheduled maintenance, plant or equipment start-up or shut-down, extreme weather conditions, utility disruptions, visits to workplace, temporary arrangements and many more. Incident reviews, safety tours and inspections, making observations of behaviour and work practices; interviews, surveys and participation of people, past experience of the organisation and experience of other organisations performed similar works compose the typical sources of information for identification process. A multidisciplinary competent team was required to perform the overall hazard or aspect identification, risk assessment and determining controls process.

In the planning phase the organisation established measurable and applicable objectives which were consistent with its policy Occupational Health and Safety (OHS) and environmental system. The organisation also established a programme to achieve determined objectives and these were to be reviewed regularly and improved by adjusting or modifying where necessary. Resources such as financial and human resources or infrastructure were determined, tasks to be performed were examined, and responsibility, authority and completion dates for each programmed task were assigned in the establishment of an effective programme.

3.2.3.3 Implementation

Under implementation, the organisation developed implemented and maintained procedures to cover resource allocation, training, documentation and emergency related issues. These were developed by various departments and were meant to be adhered to on a daily basis.

3.2.3.4 Monitoring

After the implementation of the management system, monitoring the performance of the system was initiated. Internal auditors trained in the two systems monitored the performance of the system.

3.2.3.5 Management review

Management review was the final step in completing one cycle of the management system, and it contributed to continual improvement of the system. It formed an important component covered in both standards where management considered audit reports, investigation results, feedbacks, relevant communication and follow-ups and the records of previous management reviews. On the basis of review, management was able to inform updates in polices, objectives and procedures.

Eventually the company was finally audited and certified to be OHSAS 18001 (2007) and ISO 14001 (2004) compliant by TUV Reinland in the year 2015.

3.3 Risk Assessment in Line with ISO14001 and OHSAS18001

The requirement of OHSAS 18001 (2007) and ISO 14001 (2004) (clause 4.3.1) is that a risk assessment should be conducted along with its necessary controls and an Environmental Impacts and Aspects Register or Risk register was prepared, respectively. A comprehensive risk assessment considered the effectiveness of existing controls and then evaluated the probability and the potential severity of specific hazardous events and exposures. On the basis of such an assessment, the organisation decided whether or not the risk was acceptable. An Aspect Register and a Hazard register was developed for SEC generation, transmission and distribution activities in conformance to clause 4.3.1 of the two standards. These registers enabled the company to determine significant hazards and aspects and prioritized them accordingly. These registers will also assist the company in making strategic risk management decisions in areas which require funding and ensure that the risks are prioritized.

According to OHSAS 18001 (2007), “the organisation should have a total appreciation of all significant occupational health and safety risks in its domain, after using the process of risk identification, risk assessment and risk control”. Risk analysis studies were made to determine the hazard and hazard levels in the working environment. The determination of hazards and their extent was very important in terms of which measures were to be implemented first. This whole process allowed for the anticipation and correction of risks in both environmental and occupational health and safety before they occurred.

3.4 Hazard Identification and Risk Assessment Process (HIRA)

The Hazard Identification and Risk Assessment Process (HIRA) are used in the South African mining industry to identify levels of risk. It is based on the identification of safety, health and environmental hazards, as well as on the associated safety, health and environmental risks, but with the emphasis on the frequency and severity of risks as primary parameters (OHSAS 18002, 2007).

This process framework incorporates risk assessment tools that provide for:

- Hazard identification
- Exposure assessment
- Risk characterization

3.4.1 Steps of the HIRA process

Managers or employees carrying out the HIRA process have to proceed according to the following steps in accordance with OHSAS 18002, (2007).

- Agree on the terminology to be used for safety, health and environmental hazards.
- Agree on the terminology to be used for safety, health and environmental risks.
- Draw up parameters for severity and frequency.
- Draw up a matrix, and agree on format and plotting.
- Observation of hazards by breaking up each process or activity into its component parts, and then enumerating and listing hazards.
- Plot these on the matrix.
- Draw up a profile of risks.
- Check for existing controls and affectivity risks
- Adjust risks accordingly and draw up final risk profile.

This tool was used in the development of the HIRA for the electricity sector. It was modified and a simpler version was developed.

3.4.2 Risk Rating

Risk rating in risk assessment, is the process of estimating the frequency and severity of adverse effects likely to occur due to actual or predicted exposure to workplace hazards. It is the final product of the risk assessment process which is used to develop and prioritize control strategies, and to communicate risks. One of the most critical steps is to determine whether the level of risk is tolerable by assigning a risk rank-level to the situation under review. The estimations are either defined in qualitative, quantitative or semi-quantitative terms, expounded upon below;-

Qualitative ranking: Analysts use their judgment while applying a simple ranking mechanism of "low", "moderate" or "high". This is especially useful when performing a "baseline” type of risk assessment where the object is simply to identify the "significant" risks which are then more comprehensively measured and/or analyzed (Guild *et al.,* 2001).

Quantitative ranking: This involves the use of a mathematical equation that is an extension of the low, medium and high ranks, and describes risk as a frequency of deaths. It may not be any more precise than the semi quantitative option described below (Guild *et al.*, 2001).

Semi-quantitative ranking: This method involves the use of a matrix based on the rating of hazards, and the rating of likelihood of exposure. Risks can be rated as low, medium or high. This provides a useful means for ranking risk on a comparative scale, and it is more practical than the quantitative method (Guild *et al.,* 2001).

For this study the semi-quantitative approach was used to rate the environmental risks identified in the electricity sector processes. This estimation enabled the organisation to position the risk activity within the risk matrix, and in doing so to determine the acceptability of the risk according to one of three categories:

- High risk, where immediate action is required no matter what the cost.
- Medium risk, where further reduction of risk is necessary, but where it could be dealt with in the medium to long-term period.
- Low risk which takes into account those impacts that have controls in place that need to be monitored and reduced to as low as reasonably possible.

3.5 Conclusion

In this chapter ISO 14001 (2004) and OHSAS 18001 (2007) have been presented as systems used to undertake an environmental risk assessment for Swaziland Electricity Company, the case for this study. The company as one of its strategic objectives had to implement the above systems. This was observed to be an appropriate tool for risk identification, risk assessment and risk control processes in the company. It was appropriate and adequate, and allowed organisation to identify, evaluate and control their environment, occupational health and safety risks on an on-going basis.

The main argument presented in this chapter is that the components of the standards in clause 4.3.1 namely; identification of environmental aspects or hazards associated with the company's activities, risk assessment, a process of evaluating the risk arising from the hazard and aspects and determination of applicable controls to eliminate or reduce risk to an acceptable level based on the hierarchy of control measures are a foundation of the standards and are key in the management of risks. Hence the focus of this study was on clause 4.3.1 of both standards.

This resulted in the development of risk profiles in the form of Hazard register and Aspect register which met the requirements of the above clause 4.3.1. The registers identified risks, evaluated, prioritised them and provided controls for each of the risk associated with the company's activities.

The next chapter describes the detailed methodology used in carrying out this research.

4 CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The purpose of the study was to assess the main environmental risks which are (occupational health and safety and environment risks) associated with the electricity sector. For this reason some divisional processes within this sector that were identified to have significant risks to the environment, occupational health and safety of employees were considered. Therefore, an environmental risk assessment was conducted for all the processes associated with generation, transmission and distribution of electricity at Swaziland Electricity Company (SEC). This was done to attain one of the main company's objectives, which is to ensure effective management of enterprise risk, mainly focusing on intangible risks (health, safety and environmental risks) and compliance with SEC policies, procedures, relevant local legislation and regulations, international standards and conventions.

This entailed the evaluation of risk factors relative to the organisation's compliance obligations, using tools selected for voluntary standards ISO 14001 (2004) and OHSAS 18001 (2007) and best practices to which the organisation has committed (SEC, 2012).

This chapter describes the research design and methodology used in carrying out this research. It presents the research approaches and the justification of the method opted for in this study. Section 4.2 presents the systematic approach used in this research whilst Section 4.3 describes the study research design. A brief presentation of the developed simpler risk assessment tool is made in Section 4.4. Section 4.5 discusses the reliability and validity testing of the tool whilst section 4.6 presents the ethics approval process of the study. Finally, Section 4.7 concludes the chapter.

4.2 Research Approach

This research generally followed a systematic and logical approach. According to Fellows and Liu, (2003), there are two principal approaches to research namely; qualitative and quantitative. The qualitative and quantitative methods were used in this research because they have distinct advantages associated with them while at the same time avoiding the weaknesses of each.

4.2.1 Quantitative and qualitative approach

This study explored the environmental risk assessment phenomenon in the electricity sector and developed a simpler tool for the risk assessment methodology. It sought to identify risks associated with various processes in the generation, distribution and transmission departments in the electricity company. The quantitative research method enabled the researcher to come up with a deductive and objective view of the study; where a formalized procedure was used to identify risks using risk analysis methods. The numerical value assigned to any aspect of the evaluation could be directly aligned to a measurable quality aspect. That is, rating a hazard as 1 meant it was extreme and required to be prioritized. Aspects that rated above 15 and 20, were considered to be significant and needed controls to be effected within three months.

The qualitative approach on the other hand, was employed during brain storming sessions where the teams had to identify, rate and prioritize risks against an established criteria. The team used a 5x5 risk matrix, which had columns and rows with the consisting of probability, severity and consequence. The cells were assigned risk scores that purport to represent a quantitative assessment of the risk. Figure 4.1 shows the risk rating matrix and that the higher the score the higher the risk.

Risk Rating Matrix

Red	High	17-25
Blue	Medium	8-16
Yellow	Low	1-15

Severity

Frequency						Rating	Impact on Business activities	Nature of incident (Past and future potential)	Nature of loss /damage (financial)	Legal Impact	Nature of ecological impact (environmental)
	5	10	15	20	25	5	Catastrophic downtime process delay	Fatal injury Several	Devastating dangerous R1m to 10m	International pressure	Irreversible Ecological damage and/or social damage
	4	8	12	16	20	4	Critical down time process delay < a month	Disabling injury >3days	Widespread damage between <R1million	National government pressure	Major incident potential reversible environmental damage and permanent impact on community
	3	6	9	12	15	3	Serious downtime process delay < week	Disabling injury <3days	Widespread damage between <R1million	Provincial government pressure	Short term ecological disturbance and or restricted impact to communities
	2	4	6	8	10	2	Minimal or Zero downtime process delay >day	Minor injury	Minor damage loss <R50 000	Local authorities reaction (organized)	stress to the community
	1	2	3	4	5	1	Medium downtime process delay >day	No injury	Insignificant damage or zero loss	Individual complaints little or no reactions	Minimal or zero consequences. Ecological nuisance or
Description	Name	Low likelihood	Can Happen	Probable	Regular						
Probability	Could happen once in 5yrs	Could happen once a year	Could happen once a month	Could happen once a week	Could happen once a day						
Frequency	1/5 years	1/year	1/month	1/week	1/day						
Rating	1	2	3	4	5						

Figure 4.1: Risk rating Matrix

The teams also identified existing controls and proposed controls where risks had to be reduced from high to medium or to an acceptable or tolerable level. The qualitative method gave the respondent the opportunity to speak freely, which provided important data that could not be obtained by the quantitative method. The qualitative approach used in this study took into account factors which could not be scientifically measured. These relied on experience and opinion. For instance the teams had to identify existing controls for identified risks and propose additional controls. The quantitative approach also ensured that viewpoints of cross sectional employees were taken into consideration when values such as low, medium or high were considered.

4.2.2 Systematic Approach

The risk assessment tools used for the hazards and aspects proved to be systematic as it followed a clear procedure on the steps to be followed. The activities in each process were identified as well as associated inputs and outputs. The hazards and aspects associated with each process were identified. The procedure was structured but not easy to follow, more especially the terminology used for the criteria. It was not very easy for people without training on health, safety and environment to follow easily and understand. The risk assessment processes were also consultative in nature, different viewpoints were also taken into consideration and a consensus was used to come up with a rating for the risk or impact.

4.3 Research Design

The research design guide is illustrated in Figure 4.2, it includes the data collection, analysis and interpretation of observations. It focused on exploring the occupational health, safety and environment practices and risks within the electricity industry, with emphasis on developing a simple tool for risk assessment. The research design had two components; the pilot study and the case study.

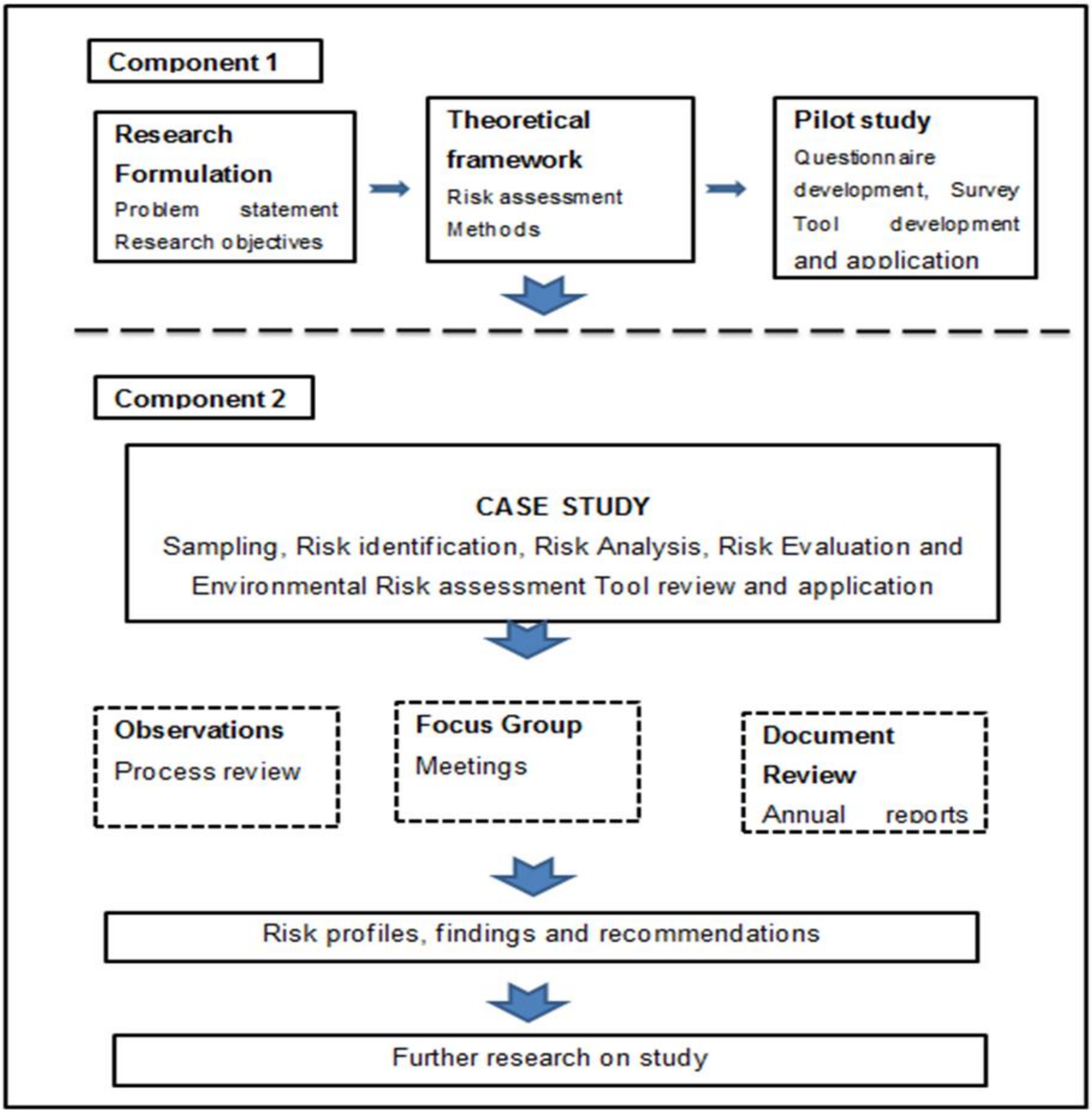


Figure 4.2: Research design for this study

4.3.1 Problem statement and literature review

The research design commenced with the identification of the research problem and the formulation of theoretical, as well as conceptual structure developed through the review of existing theory and models in literature. The literature survey was done throughout the course of the study and it was to understand the concept of environmental risk assessment.

Through literature relevant to the subject matter, models were identified. The literature search involved a thorough review of current practices and previous research in the area of environmental risk assessment.

The rational of the study was also attained from the literature survey. The basic sources for the collection of the secondary data for this study included scientific databases and journals related to the topic of research as well as reports and publications from the industry and governmental agencies. Annual reports were used to obtain information about the company, the company's structure and organisation (such as the nature of business, annual turnover and risk management approach) in order to create value to the business entity.

4.3.2 Pilot study

The second stage of the research design was the interview survey where questionnaires were used. The questionnaires were first developed and later piloted.

4.3.2.1 Questionnaire development

The development of a questionnaire is a major task in empirical research. When developing the questionnaire, the questions were carefully worded, easy to understand and straightforward. The questionnaire from this study was developed to answer the objectives of the study. It consisted of general and risk management information pertaining to SEC operations. The first section consisted of general information that identifies the background of the respondent. The second section investigated the environmental risks associated with activities the respondent is involved in. A sample of the questionnaire used in this study is shown in Appendix 4.

The questionnaire was user friendly and probed areas of improvement on the risk assessment tool to which were then used in this research. Some of the advantages of using the questionnaire research method includes its wide application, convenience and being inexpensive. In addition this was a favourable method to the respondents since the questions asked, were easy to understand and convenient to respond to. The questionnaire method also provided anonymity to respondents.

4.3.2.2 Piloting the questionnaire

Once the questionnaire was developed, it was piloted. According to Sekeran (2003), the main purpose of pilot testing was to determine the feasibility of the questionnaire. The study questionnaire was tested in the Safety Health Environment and Risk and Quality (SHERQ) department where there was expertise in risk management, quality, occupational health and safety and environment fields. The supervisor/promoter was also given the copy to comment. This piloting exercise checked the length, content and sequence of the questionnaire. No major changes were made on the questionnaire.

The main objectives of conducting the interviews were to determine the understanding of SEC employees on occupational health and safety risks and environmental risks, their sources and how they are currently managed. The other part of the questionnaire was designed to obtain the profile of the respondents with regards to their level of education, their gender, experience and exposure to occupational, health and safety as well as environmental training.

The data obtained from the interviews using questionnaires was analyzed and is presented in Chapter 6. This data provided the researcher with the critical risks that required further investigation in the research.

4.3.3 Case study

The case study was undertaken using the implementation strategy that is explained in the next section.

4.3.3.1 Research Implementation strategy

Leedy *et al*., (2005) suggest that a research strategy is the mechanism used by a researcher to collect, collate and interpret data. The main aim was to undertake the risk assessment in the following selected departments: generation, transmission and distribution by interviewing certain groups so that the results could be generalized for the study. The study included the following activities:

- Conducting a pilot survey with SHERQ department to test the risk assessment tool;
- Conducting focus group meetings and interviews with target respondents;
- Questionnaire survey involving the distribution of the questionnaire using e-mail, along with a covering letter explaining the purpose of the study and requesting the head of departments to participate in the survey;
- Conducting a physical visit or walkabout in various workstations to gather more data such as pictures and observations;
- Revising the risk assessment tool to incorporate comments from respondents;
- Following up non-respondents by e-mail and telephone;
- Compiling and analyzing the questionnaire results; and
- Development of a risk assessment tool

4.3.3.2 Sampling Frame

The study explored the environmental risks associated with the generation, transmission and distribution business units within SEC. It employed qualitative and quantitative research techniques to arrive at the purported objectives. It applied triangulation using one on one interview, a focus group and site visits. Sampling, as opposed to a census strategy, was selected as the method whereby selected teams were used in the investigation. The main advantages presented by the sampling method of the study population included the fact that; the investigations were thorough and were carried out with speed when compared with a complete coverage.

4.3.3.2.1 Sample selection

When conducting the survey it was important to consider the selection of sample population. In this research study, sampling of the population was done by systematic sampling involving the various business units of the company. The company generally has the following divisions; Operations, Customer Services, Finance, Support services, Research Development and Strategy, Managing Director and Corporate services. The sampled sites generally represented the core functions of the operations division that is: power generation, transmission, and distribution. The generation sites were Edwaleni and Maguduza, distribution (Stonehenge, Big Bend, Matsapha, Nhlangano) and transmission (Thompson and Mkhinkhomo substations) and the 132 kV line routes.

The sampled population included professionals at functional level/line management level from diverse disciplines, engineers, electrician's office workers, environment and safety as well as, health representatives. The respondents were selected because of their expertise or authority as well as responsibilities in their work areas. The population consisted of 360 employees from the operations department (generation, transmission and distribution) focus group meeting. A total of 40 managers were issued with questionnaires whilst 54 employees were interviewed using the questionnaire.

4.3.3.3 Data collection techniques within the case

The case study used three main research techniques namely; interviews, observations and document review as sources for evidence collection in the various sites. The researcher had to take cognisance of ethical issues and ensure those participating in the research had freedom to do so. Also their privacy and confidentiality had to be maintained. This was communicated to the respondents prior to interview data collection. A consent letter from the Swaziland Electricity Company's, Managing Director was shown to all respondents prior to undertaking surveys, observations or taking photos (refer to Appendix 1).

The first survey was administered to functional / line managers and professionals of various units which included Operations, Customer services, Finance, Support services and Corporate services and teams or focus groups from various departments. To obtain a better understanding of business units (generation, transmission, distribution and support services) activities and their environmental risks, on-site observations were done. During the on-site observations, the potential risks were identified with team members who were selected based on their specific level of expertise and assist during the walk of their facility and operations. Table 4.1 depicts the data collection schedule.

Table 4.1: Data collection schedule

ACTIVITY	SCHEDULE	RESPONSIBLE	OUTCOME
1.Focus groups and site visits -Workshops -brain storming sessions -site visits	20 June 2014 to January 2015	Candidate	Risk registers
2. Interviews	20 - 31 January 2015	Candidate	Filled questionnaires
3.Tool development	25 February- 20 March 2015	Candidate	New tool
4.Testing of tool in focus group Interviews	10 April 2015- 20 July 2015	Candidate	Updated risk registers
5.Data analysis	30 September -10 October 2015	Candidate	Analyzed results

4.3.3.4 Questionnaire surveys

Data was collected using questionnaires. These were administered to 40 head of departments and managers in functional and line management positions who were part of the survey. The questionnaires were e-mailed accompanied by the covering letter including an assurance of anonymity for the expression of strongly held views.

4.3.3.5 Focus groups meetings

According to Rwamamara (2007) an effective risk management process should be managed by a cross-disciplinary team, and be supported by free and open communication and consultation between the project stakeholders. Team brainstorming sessions were undertaken in order to ensure that all relevant information gathered are valid, non-biased and reliable in terms of accuracy and reliability. This process allowed the risk to be mapped to the business area affected, describes the primary control procedures in place and indicates areas where the level of risk control investment might be increased, decreased or reapportioned. In this regard, the section heads and supervisors for various sections and departments within SEC were selected when conducting the risk assessments to reduce bias information.

The team members were first taken through a presentation on risk assessment using the two standards, ISO 14001(2004) and OHSAS 18001 (2007) which the company was implementing. They were taken through two procedures for undertaking risk assessment. The teams then brainstormed to identify their activities and evaluate the risk associated with their activities. The brainstorming sessions were accompanied by site inspection around their premises to identify environmental risks in their sites. The site visits supported the brainstorming sessions conducted from actual versus theoretical information.

The team undertook the risk assessment following the Deming cycle and included:
(1) a hazard / aspect identification, where all outcomes potentially leading to harm to humans or environmental damage were charted; (2) an estimation of the magnitude of the consequences associated with the above outcomes; (3) an assessment of the probability of each of the outcomes; and (4) a risk evaluation, where the results from the first three elements were evaluated and integrated to form a risk picture. The possible risks deemed likely to occur were rated in terms of impact (or severity) and likelihood (or probability), both on an inherent basis and a residual basis. The results were compiled to provide a risk profile. This enabled the company to develop response strategies and allocate its resources appropriately.

The procedure attached in Appendix 4 adopted from Newbury (2006) and the forms were developed for hazard and environmental risk assessment tool. This procedure was developed from clause 4.3.1 of the ISO 14001 (2004) Environmental management system and OHSAS 18001 (2007) the Occupational Health and Safety Assessment Series. The clauses require that aspects or hazards must be identified and the risks and impacts associated with process must be evaluated and that the effectiveness of controls that are existing must be assessed. This ensures that the risks are controlled or reduced.

The procedure identified, classified and rated risks based on the above mentioned standards. The risk criteria included concerns, associated costs and benefits, legal requirements, socio-economic and environmental effects, concerns of stakeholders and controls. The procedure ensured that site risk exposures were identified and that public concerns for interested and affected parties were taken into consideration during the assessment. The procedure was also proactive in nature but it had the following short comings;

1. The procedure was tedious, teams had to fill in too many forms (Aspect identification form, Aspect evaluation form, objectives and tiger consideration form and an Aspect register).
2. The significance in the Aspect Register was exaggerated and it was not easy to pick up and prioritize the most significant risk
3. The main aim of an environmental risk assessment is to inform decisions as to whether any existing control measures are adequate or whether additional prevention or control is required. Even though in this procedure the existing controls were identified, it was not easy to determine how much controls were needed to further eliminate, or reduce the risk to an acceptable level or tolerable level.
4. The procedure failed to indicate the level of control measures required.
5. The residual risk which is the effectiveness of the controls subtracted from the pure or raw risk was never considered.

4.4 Development of simpler risk assessment tool

This research proposed to develop a simpler (user friendly) environment risk assessment tool based on the gaps of the one by Newbury (2006), and other researchers. The tool was developed for hazards and aspects and is presented in Table 5.8 and Table 5.14. The developed tool is detailed in Chapter 5. The effectiveness of the tool was tested on SEC employees.

The tool was simplified yet relevant and useful for its intended purpose to identify, evaluate and analyses environmental risk in the electricity industry. The new tool factored in other important elements that were not considered in the model used by Newbury (2006). The Table 4.2 below gives a summary of the difference between the two tools.

Table 4.2: Differences between Newbury (2006) procedure and developed tool

Newbury 2006	Developed tool
It is cumbersome the teams or focus groups undertaking risk assessment need to fill in lots of forms	Simpler only few spread sheet are filled by focus groups undertaking the environmental risk assessment
The tool was not on effectiveness of controls that are in place. The tool does not adequately take into consideration the existing controls only the pure risks	The tool specifies the existing controls. The risk significance is determined by considering the pure risks and existing controls which then gives residual risk.
It uses a matrix to evaluate the risk, this sometimes results in the exaggeration of some of the risks.	Does not use a matrix instead the parameters are added

4.5 Data analysis

The data obtained using the questioners and focus groups meetings was subjected to quantitative analysis. Variables such as employee's skills, educational background, age, work experience exposure to environmental health and safety training, were used to determine the environmental risks associated with the transmission, distribution and generation of electricity.

4.6 Reliability and validity

The study had to take in to cognizance the challenges which are usually associated with research which are reliability and validity. This work ensured the reliability and validity of data using approaches such as surveys, interviews using questioners and focus groups sessions using experienced employees. Another approach that was used was triangulation where observations were made on processes in the various sites and through document review.

4.7 Ethics approval

It is a requirement of the University of South Africa that all research studies involving human subjects must have written approval from the University's Ethics Committee. An application was made to the ethics committee and approval was granted to undertake this study, herewith attached in Appendix 3.

4.8 Conclusions

The methodology used to conduct this research has been explained in this chapter. The chapter presented two research approaches; qualitative and quantitative methods. The justification for the choice of the research approach, style and methods has also been clarified. The research design with its two components was discussed which are literature review, a pilot survey and the main study. The sample frame and population, data collection process and challenges experienced have also been highlighted in this chapter. The research paradigm strategies and issues relative to reliability and, validity of this research have been discussed. The next chapter presents how the simplified environmental risk assessment tool was developed and applied.

5 CHAPTER 5: DEVELOPMENT AND APPLICATION OF TOOL FOR ENVIRONMENTAL RISK ASSESSMENT IN THE ELECTRICITY SECTOR

5.1 Introduction

One of the main objectives of this study was to develop a tool for environmental risk assessment in the electricity sector. The tool was presented in this chapter and applied and tested for viability. The results from the risk assessment were used to develop the proposed tool for environmental risk assessment in the electricity sector. The flaws or limitations identified in the tool presented in chapter 4 and appendix 4 were improved upon, resulting in an enhanced risk assessment tool, which effectively address legal compliance and ensure that risks are managed effectively. This proposed tool emphasized on the bigger component of risk management which is risk assessment. It has sub phases risk analysis and risk evaluation. Other components of risk management such as monitoring and communication are briefly discussed.

5.2 Scope of environmental risk management methodology

The scope of the methodology for environmental risk assessment is based on two standards namely ISO14001 (2004) an Environmental Management System and OHSAS 18001 (2007), Occupational Health and Safety Management System. It is also premised from the provisions of the Swaziland Environmental Management Act (2002) and the Occupational Health and Safety Act (2001).

The Swaziland Environmental Management Act (2002) section 5, requires that the precautionary principle must be employed where adverse effects should be prevented and minimised through long term integrated planning and the co-ordination, integration and co-operation of efforts, which consider the entire environment as a whole entity by organisation. The other is the precautionary principle, which requires that where there is a risk of serious or irreversible adverse effects occurring, a lack of scientific certainty should not prevent or impair the taking of precautionary measures to protect the environment.

The Swaziland Occupational Health and Safety Act 2001 section 3 requires that an employer shall ensure that, there is a systematic way of identifying, evaluating and controlling hazards at the workplace and such systematic ways are functional at all times. The Act places a responsibility on the employer to ensure that his activity has minimal impact on the environment by ensuring safeguard of the health and safety of his employees and to ensure that the risk to which they are exposed to is as low as is reasonably practicable.

The employer is also required to make a suitable and sufficient assessment of risks related to the health and safety of his employees and others who might be affected as well as conduct a detailed environmental assessment to identify aspects and impacts related to his processes. Hence, it was important to come up with a simplified, easy to use tool for environmental risk assessment to be used in electricity generation, transmission and distribution industry.

5.3 Risk management process

The study seeks to present a risk management tool that focuses on risk identification, risk evaluation and risk control. Different authors have proposed different processes to be followed when managing risk in an organisation. Holmes, (2002) refers to four continuous stages namely identification, quantification, managing or responding to risk and finally monitoring or controlling. Additionally, Valkamis *et al.,* (1999), state that there are four steps namely risk identification, risk evaluation, risk control and risk financing. On a different note Kipp and Loflin (1996) came up with five steps being risk identification, risk evaluation, establishment of priorities, risk control and monitoring. The common factor from the authors in risk management process is that they all take a problem solving approach. This ensures that the problem is identified, analysed to determine the extent of the problem, solutions are generated and the best solutions are implemented. This study has also employed this above mentioned problem solving approach.

5.3.1 The Risk assessment process

Generally, risk assessment as explained in Chapter 2, is a systematic process which involves identifying the hazards or aspects present and then evaluates the risks involved, taking into account whatever precautions which are already being taken. The next step involved assessing risks with the objective of determining their relative priority or impact. The processes were followed by the determination of what had to be done about risks in order of priority. Meaning that mitigation or control measures were sought and the best one was implemented. Finally monitoring protocols were implemented to ensure that the risk management process achieves the objectives of what it was set to do. This step was critical to ensure that the loop was closed so that the risks were continually assessed and managed to a point where all pure or raw risks are controlled and speculative risks were exploited to derive maximum benefit to the organisation. Additional actions were taken to eliminate the hazards or aspects to reduce the risks. The process mentioned above was followed when developing the environmental risk assessment for this study.

When carrying out the environmental risk assessment, there was need to consider what hazards or aspects could arise and why, who could be harmed and how, whether the existing precautions were enough and, if not, what more had to be done. Therefore, the assessment consisted of the following main steps adopted from the Australian /New Zealand standards (2004).

1. Establish context (develop criteria and structure)
2. Identify hazards and aspect (what can happen, where and how, why?)
3. Analyse the risks (identify existing controls , determine consequences and likelihood and attain level of significance)
4. Evaluate the risk, compare the risk against set criteria and set priorities
5. Treat the risk and or analyse and evaluate significant risk

The environmental risk assessment at Swaziland Electricity Company (SEC) took into account contractors and visitors, having access to (SEC) premises and facilities.

Various industries carry out some form of risk assessment on a day to day basis prior to undertaking operations. During the course of their operations, they will monitor the situation, recognise problems as they develop and introduce corrective measures by either taking immediate action or by implementing longer term solutions. These fundamental risk assessment principles have been built upon in the methodology presented herein.

When developing the tool, due considerations were taken to the reality that there are no fixed rules about how environmental and occupational health and safety risk assessments, communication and control should occur. It was however, noted that, there are some general principles that should be followed. Several researchers have developed risk assessment methodologies to suit their requirements (Huges and Ferret, 2011; Lingard and Rowlinson, 2005; and HSE, 2004). However, regardless of the differences in approaches or industries, most of the risk assessment methodologies are similar with respect to the basic principles, and contain the key components which include work analysis, hazard identification, risk estimation and risk evaluation.

5.4 Adopted risk assessment process

The developed methodology is aligned to the above principles and the steps followed in the risk assessment process were as follows: planning, selection of the risk assessment team, hazard or aspect identification, converting hazards or aspect to risk, ranking the risks and evaluating the effectiveness of the controls. The risk assessment process was developed for occupational health and safety (hazards) and environment (aspects) which are collectively termed environmental risk assessment in this study. These processes are expounded upon hence forth.

A. Planning

The scope of the risk assessment process was developed in line with the OHSAS 18001 (2007) and ISO14001 (2004) standards Clause 4.3. The Hazard and Aspect registers (Appendix 3) were developed and filled in by the risk assessment teams on site, where they had to identify all operational activities. The team consisted of the head of department, and employees competent and knowledgeable of the operations and activities in the department. Therefore, the team had a clear understanding of their role, a good understanding of the risk assessment methodology, ability to identify the main hazards and aspects associated with processes of their departments. There was also expert input from representatives from the environment and safety department.

B. Hazard or Aspect identification

The next step was the identification of aspects and hazards involved in the process or tasks being assessed in each department. The teams and researcher had to identify all hazards and aspects associated with their processes. They screened the hazards and aspects to determine significant and non-significant hazards and aspects. They had to also consider changes that have occurred in processes to determine new risks.

C. Conversion of hazards or aspects to risk

Once the hazards or aspects were identified, the associated risks and impacts were established respectively. This was critical to ensure that the risks were assessed not the hazards or aspects.

D. Risk evaluation

To ensure consistency in the environmental risk assessment a risk evaluation methodology was developed for occupational health and safety and the environment. This ensured that risk profiling was done in a value adding basis in all the departments investigated. After identifying the risks, the teams and the researcher then analysed or evaluated the risks. The risk analysis involved consideration of risk consequences and likelihood that those consequences could occur. The main purpose of the risk analysis was essentially to objectively establish the priority of actions required in order to eliminate or minimise identified risks to acceptable levels. When ranking the hazards, the team's knowledge of the workplace activities, urgency of situations, and objective judgment was used.

E. Risk controls

Once the risks were assessed, controls were identified and evaluated in terms of their effectiveness following the hierarchy of control methods. The effectiveness of the control measures indicated the level of risk exposure and helped identify additional control measure requirements. Such controls included engineering, administrative and PPE controls. The hierarchy of the controls were effected and controls that were of most value to reduce the risk to tolerable levels were communicated to all role players from different departments; see Figure 5.1.

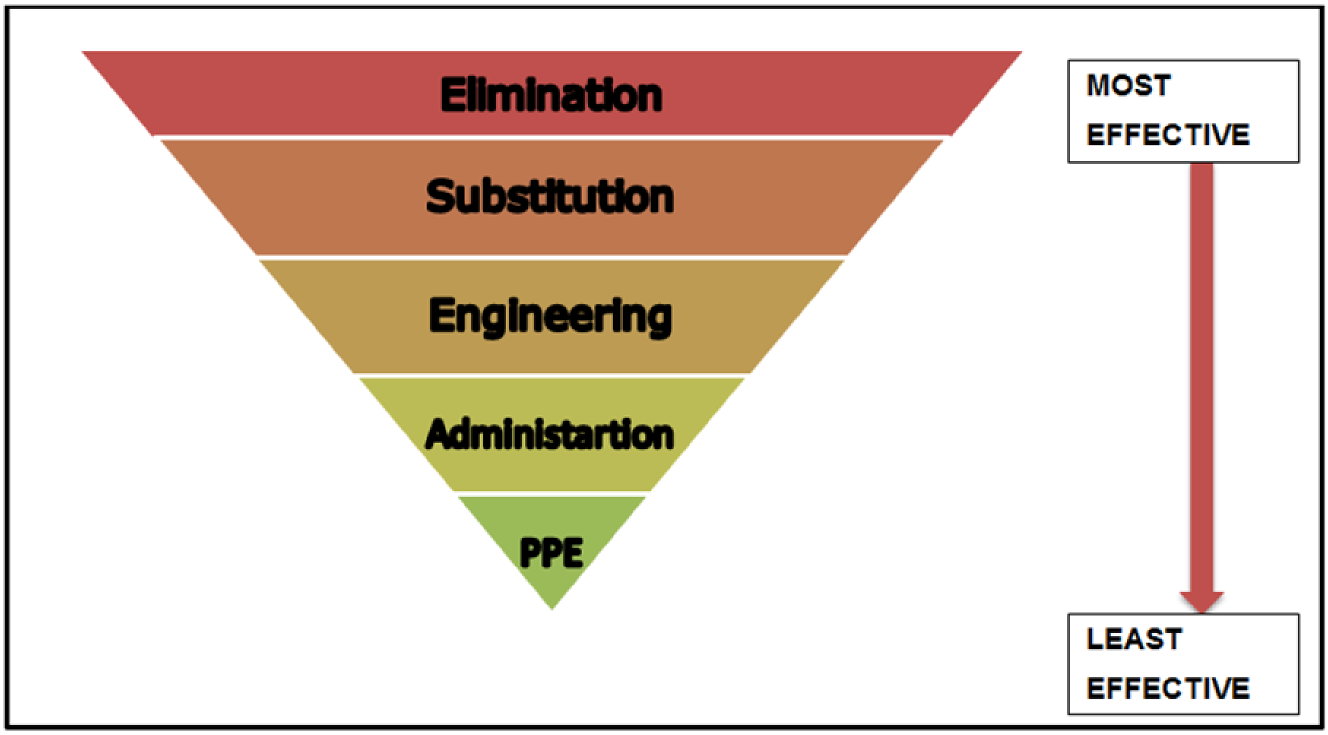


Figure 5.1: Hierarchy of controls

The risk assessment approach has been designed for the environment and occupational health and safety are shown in the flow charts in Figure 5.2 and Figure 5.3. It differs from the conventional methods of risk assessment in that after identifying the tasks and activities, as well as associated aspects and risks, the following risk analysis criteria were used; public concerns, frequency, applicable legislation, impacts of aspects as well as existing controls. These were used to determine the level or significance of risks and provide recommendations for decision makers for those departments. The information was captured in aspect or hazard registers. The next section gives a step by step risk assessment followed for the occupational health and safety and the environment at SEC.

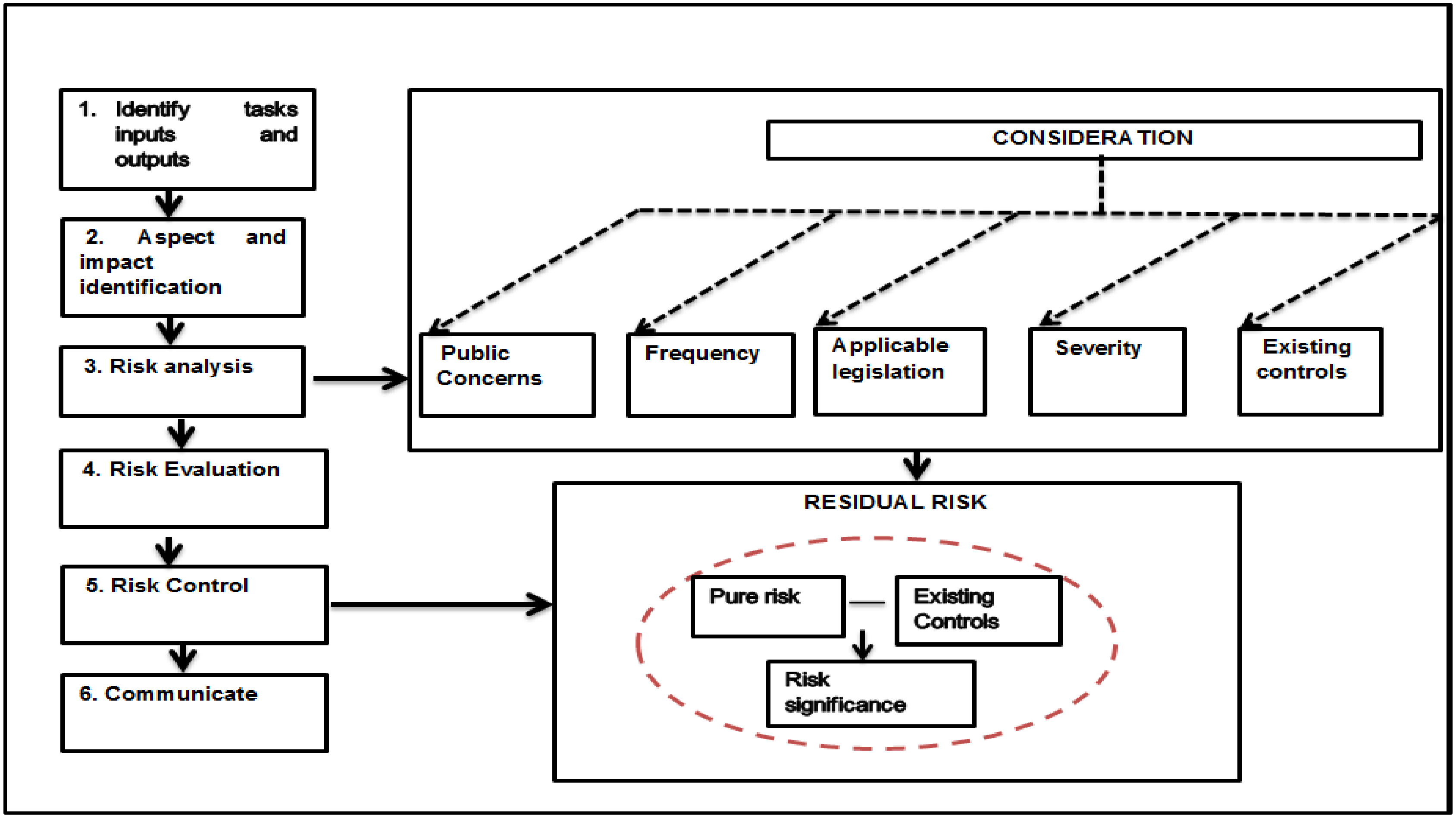


Figure 5.2: Process flow chart for Risk Assessment for the Environment

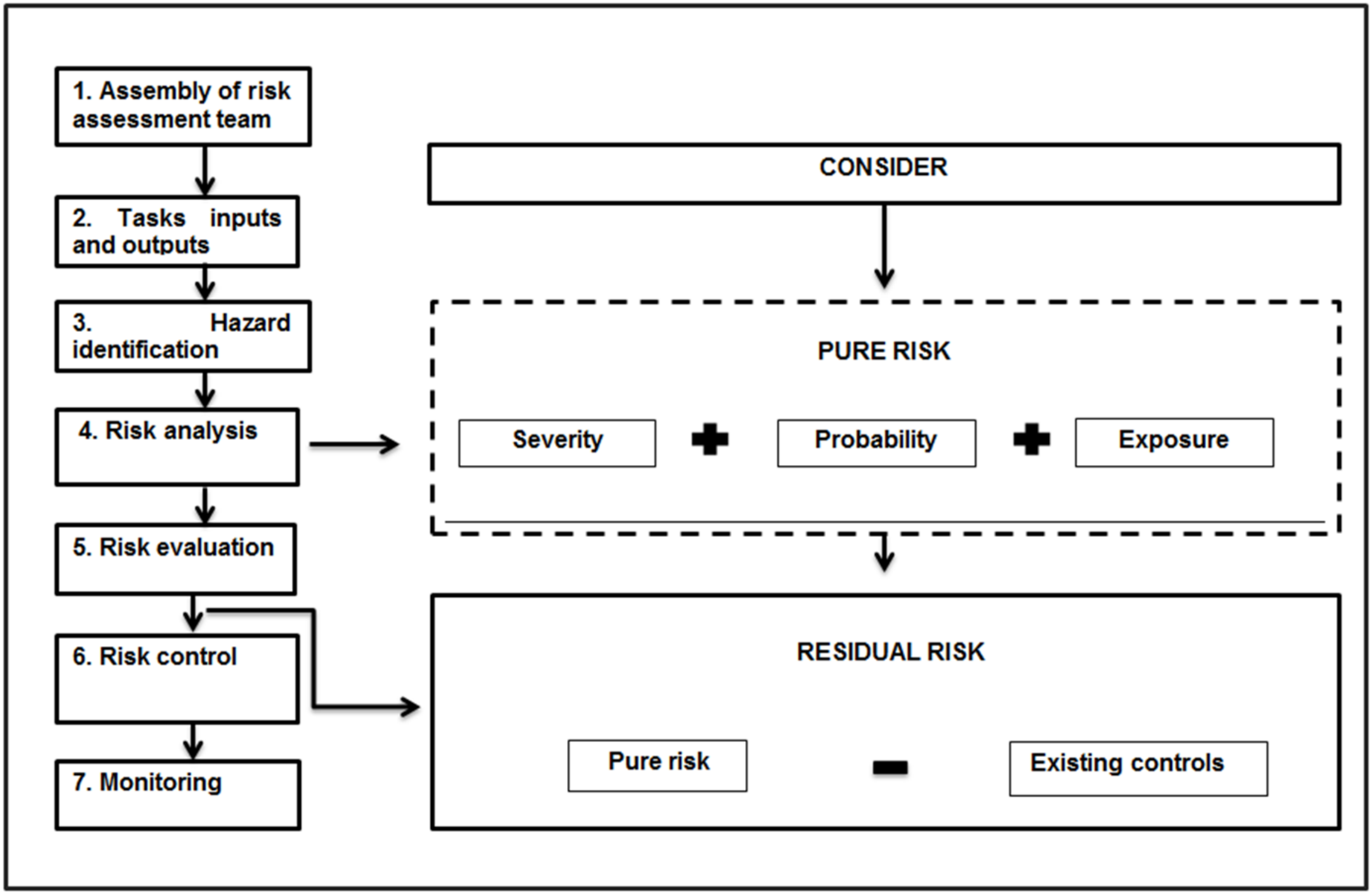


Figure 5.3: Showing Risk Assessment Tool for safety

5.5 Risk evaluation methodology for Environment

5.5.1 Aspects and Impacts Identification

The site team and head of department led by the researcher (environmentalist) determined the core processes, activities, tasks and services within their site/function/unit. Inputs and outputs of all the determined processes, activities, tasks and services were listed in a form called the aspects register as shown in Table 5.7. From the listed inputs and outputs, aspects were identified and, thereafter actual or potential impacts were determined and indicated.

5.5.2 Aspects/Impacts Evaluation and Significance Determination

The purpose of the impact evaluation process was to identify and evaluate the significance of the identified environmental impacts associated with the particular activity. This was done according to the criteria given in the next section. Measures were identified that avoid or minimise adverse effects and enhance environmental benefits. The residual impacts are those impacts that remain even after mitigation. The impacts are described in terms of significance which is usually the function of the magnitude of the impact, or likelihood of impact to occur. The impact magnitude is sometimes referred to as severity (a function of extent, duration and intensity of the impact). This was done according to the criteria shown in the next section.

The risk evaluation process was carried out by a selected team of competent personnel depending on the issues being addressed. Each identified aspect was assigned a rating from 1-4 to indicate the relative importance of its related environmental impact using the criteria discussed below. The risk evaluation methodology was assessed using the scoring tables (Table 5.1 to 5.6) developed from a risk assessment process by Newbury (2006) and are shown in the next section.

Criterion *1= Legislation and/ or other requirements*

Is the identified aspect applicable to the country's environmental legislation and or other legal requirements the company subscribes to?

Table 5.1: Criterion for Legislation and or other requirements

Score	Description	Definition
1	Insignificant	Applicable to neither
2	Minor	Could be (Lack of awareness)
3	Moderate	Applicable to either one
4	Major	Applicable to both legislation and other requirements

Criterion 2= Concerns of interested parties

Is the identified aspect a concern to the surrounding community, stakeholders etc.?

Table 5.2: Criterion for Concerns of interested parties

Score	Description	Definition
1	Insignificant	Not a concern
2	Limited	Could become a concern
3	Moderate	Some interested parties may be concerned
4	Significant	Serious concern to interested parties including political or activities, intense negative media, public anger/lawsuits etc.

Criterion 3= Impact of aspect on the environment (severity)

What is the effect of the identified aspect/impact on the environment?

Table 5.3: Criterion for Impact of aspect on the environment (severity)

Score	Description	Definition
1	Insignificant / negligible /minor	Minor consequences/ easily correctable
2	Moderate /Marginal:	Small potential impact but correctable
3	Serious	Likely to significantly damage the environment. Difficult, but possible to remediate
4	Critical/ catastrophic	Wide spread damage to the environment and requiring great effort to remediate or correct

Criterion 4= Frequency

How often does the identified aspect occur?

Table 5.4: Criterion for Frequency

Score	Description	Definition
1	Unlikely/Rare	Minor consequences/ easily correctable
2	Possible/ Regular	Small potential impact but correctable
3	Likely/ Occasional	Likely to significantly damage the environment. Difficult but possible to remediate
4	Frequent	Wide spread damage to the environment and requiring great effort to remediate or correct

Criterion 5= Controls

Are there any existing controls/mitigation measures? (Operational controls, administration controls, engineering controls, permits etc.)

Table 5.5: Criterion for Controls

Score	Description	Definition
1	None existent	No controls in place
2	Limited	Limited controls: e.g. Administrative controls only in place
3	Moderate	Moderate controls: e.g. Administrative and Operating controls in place
4	Full control	Full controls: e.g. Engineering controls, Administrative controls, Operating controls and or other controls in place

5.5.3 Significant risks

Significant aspects were determined as those with a priority score between 12 and 16. The following table was used as a guide to determine timeframes and appropriate action to be undertaken for the different priority environmental aspects and impacts identified. Actual timeframes were agreed upon with the different risk assessment teams.

Table 5.6: Time frames to action risks

Total score	Level of significance	Action	Time-frame
1 -5	Low	Short Term	Monitor
6-11	Medium	Medium Term	Within 6 months
12-16	High (Significant)	Manage	Within 3 months

The intention is to reduce impacts to "as low as reasonably practicable" (ALARP)

Environmental aspects were identified through the definition of activities/tasks inputs and outputs and recorded on the Aspect register, presented in Table 5.7 to 5.9 in the next section show the aspect registers that were developed for the operations department.

Table 5.7: Aspect registers for generation department

	GENERATION DEPARTMENT ASPECT REGISTER				Condition	Assessment														
						Significance Evaluation														
No.	**Activity**	**Inputs and Outputs**	**Aspect**	**Impacts**	**Normal/Abnormal/ Emergency (N/A/E)**	Legislation	Concerns	Environmental Impact	Frequency	**PURE RISK LEVEL**	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited	(1) Nonexistent controls	Existing Controls/ Mitigation measures	**RESIDUAL RISK LEVEL**	Significance(Low/Medium/High)	**Legislation and other requirements**
1.	Generation plant operation and maintenance	Oil level status report, Manpower Hydro sets, Safe power generation Hydro sets, Safe and efficient operation of hydro sets Oil level status report Work instruction, Rotating machinery Water usage, Report book Electricity	Disposal of general waste	Soil pollution	N	3	1	2	4	10	Waste Procedures in place and trainings on waste management done				X		2	8	M	The Waste Regulations of 2000
			Spillage of oil from coolers	Water pollution	E	2	1	1	3	6	Emergency plan in place and oil spill kits			x			3	3	L	The Water pollution control regulation of 2003
			Water usage	Water resource usage	N	2	1	1	3	7	Monthly monitoring plan in place				X		2	5	L	The Environment Management Act 2002
			Electricity usage	Electricity usage	N	1	1	2	4	8	Monthly monitoring plan in place					X	3	5	L	The Environment Management Act 2002

Table 5.8: Aspect Register for Distribution Department

DISTRIBUTION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited controls	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
1.	Planned and Reactive maintenance Excavation and trenching (digging) Pole mounting Bush clearing Use of ladder and other tools/ equipment	Man Power, Erosion Tillage Repaired line Scrapped material and Contaminate Scrap Disturbed flora and fauna Electric and magnetic fields	Disposal of waste electrical component	Soil pollution	N	4	3	2	3	12	Waste Procedures in place and trainings on waste management done				X		2	10	M	The Waste Regulation of 2000
			Disposal of creosote treated poles	Soil pollution	N	4	3	3	3	13	None					X	1	12	H	The Waste Regulation of 2000
			Soil tillage	Surface-water Pollution	N	3	3	3	4	13	None					x	1	12	H	The Environment management of Act 2002

DISTRIBUTION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited controls	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Man power, route , Transport , Location	Bush clearing	Degradation / Use of biological resources	N	4	4	3	2	13	Bush clearing Guidelines in place and EIA procedure				X		2	9	M	The Environment management Act of 2002
2	New Projects Execution and Connection of New customer services Construction of a new line Surveying of a new line Routine inspection	Electric and magnetic fields (EMF), Link sticks Man power, route Transport , Location Conductor Transformer	Soil tillage	Soil degradation	N	3	3	3	4	13	None						0	13	H	The Environment management Act of 2002
			Disposal of waste (hazardous waste, scrap metal and general waste)	Soil and water Pollution	A	3	3	2	4	12	Waste Procedures in place and trainings on waste management done			X			3	9	M	The Waste Regulation of 2000
			Emission of fumes from vehicles	Air pollution	N	3	3	3	4	13	None					x	1	12	H	The Air pollution Regulation of 2000

DISTRIBUTION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited controls	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
3.	Office based activities	Man Power, Computers Office furniture Electricity and water Lighting	Disposal of Compact fluorescent lighting	Soil and water pollution	N	4	3	2	3	12	Waste Procedures in place and trainings on waste management done and crushers for bulbs				X		2	10	M	The Waste Regulation of 2000
			Over use of water and electricity	Resource depletion	N	4	3	3	2	12	None					X	1	11	H	The Waste Regulation of 2000
			Spillage of chemicals or fuels	Surface-water and soil pollution	N	3	2	3	3	11	None					x	1	10	M	The Environment management Act of 2002
		Vehicles and fuel	Emission of gases	Air pollution	N	4	4	3	2	13	None				X		1	12	H	The Air pollution Regulation of 2000

DISTRIBUTION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited controls	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
4	Transportation of materials, human and other resources to working sites, vehicle maintenance, depot maintenance and storage of material	Vehicles, fuels, chemicals fertilizers Storage facilities Contaminated soil	Soil tillage	Soil degradation	N	3	3	3	4	13	None						1	12	H	The Environment management Act of 2002
			Disposal of waste hazardous waste (oils), scrap metal and general waste	Soil and water Pollution	A	3	3	2	4	12	Waste Procedures in place and trainings on waste management done and bund areas and oil separators in place and clean up kits used			X			3	9	M	The Waste Regulation of 2000
			Emission of fumes from vehicles	Air pollution	N	3	3	3	4	13	None					x	1	12	H	The Air pollution Regulation of 2000

Table 5.9: Transmission Department Aspect Register

TRANSMISSION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited control	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
1	**Line Patrol**	Vehicle Manpower Radio (car/portable radio) Binoculars Bush knives, hammers	Access route clearance	Land degradation	N	2	2	2	1	7	Bush clearing guidelines in place				x		2	5	L	The Environment Management Act of 2002
		Stationery (files, paper, pens)	Emission of fuel gases	Soil pollution	N	2	2	2	3	9	None					x	1	8	M	The Air pollution Regulations of 2010
		Computer, printers	Disposal of waste (general and hazardous waste)	Soil pollution	N	4	1	1	1	7	Waste bins available				x		2	5	L	The Waste Regulations of 2000

TRANSMISSION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited control	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
2	Bush clearing, Line construction and maintenance	Vehicles Maintenance tools (picks, shovels, crow bars, bush knives)	Storage and disposal of waste material	Soil pollution	N	2	3	2	2	9	Waste bins available on site Waste management procedure in place				x		2	7	M	The Waste Regulations of 2000

TRANSMISSION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited control	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Creosote treated poles	Creosote treated wood disposal	Soil pollution	N	2	2	2	2	8	None					x	1	7	M	The Waste Regulations of 2000
3	Substation protection installation and Batteries and charger installation	Tools (hammer) Machinery- Mobile (crane and jack)	Spillage of battery solution	Soil pollution	A	3	3	2	2	10	Waste bins available Waste management procedure in place				x		2	8	M	The Waste Regulations of 2000
			Disposal of battery cells	Soil pollution	A	4	3	2	1	10	Waste bins available				x		2	8	M	The Waste Regulations of 2000
			Fire outbreak	Land degradation	N	3	4	4	1	12	Fire extinguishers in place				x		2	10	M	The Air pollution regulations of 2010

TRANSMISSION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited control	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
4	HV Yard Maintenance		Spillage of weed killer	Soil pollution	N	2	2	3	3	10	Waste management procedure in place				x		2	8	M	The Waste Regulations of 2000
			Used or broken Bulbs (mercury vapor , LEDs, high pressure sodium lamps, CFLs)	Soil pollution	N	2	1	2	1	6	Waste bins available Waste management procedure in place				x		2	4	L	The Waste Regulations of 2000

TRANSMISSION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited control	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
			Oil leaks from faulty transformers	Soil pollution	N	2	2	2	1	7	Waste bins available Waste management procedure in place				x		2	5	L	The Waste Regulations of 2000
			Consumption of fuel	Resource depletion	A	2	2	2	3	9	None				x		1	8	M	The Environment Management Act of 2002
5	HV isolator installation and maintenance from above ground fuel tank		Spilt lubrication spray, densal paste grease	Soil pollution	N	2	2	3	1	7	Waste bins available				x		2	5	L	The Waste Regulations of 2000

TRANSMISSION DEPARTMENT ASPECT REGISTER					Condition	Assessment – Significance Evaluation															
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited control	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
6	Power transformer installation assembling and maintenances	Man power	Contaminated waste rags	Soil pollution	N	2	3	3	3	11	Waste bins available				x		2	9	M	The Waste Regulations of 2000
		Equipment (hydraulic jacks, tiphor slippers , rails, D shekels , chain block, lever hoist , crane Silica gel	Waste silica gel disposal	Soil pollution	N	2	3	3	3	11	Waste management procedure in place				x		2	9	M	The Waste Regulations of 2000

TRANSMISSION DEPARTMENT ASPECT REGISTER					Condition															
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Aspect	Impacts	Normal/Abnormal/ Emergency (N/A/E)	Legislation	Concerns	Environmental Impact	Frequency	PURE RISK LEVEL	Existing control	(5) No need for controls	(4) Full controls in place	(3) Moderate controls	(2) Limited control	(1) Nonexistent controls	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
7	Meter installation on 400V Meter testing on site Meter testing in lab Reprogramming of meters Automated meter reading installation	Manpower Testing instruments Test benches Injector Multi-meter Portable working standard /Desk Meter (new and faulty) Digital meters	Disposal of waste meters, CTs, cables	Soil pollution	N	4	3	2	4	13	Waste bins available Waste management procedure in place				x		2	11	M	The Waste Regulations of 2000

5.6 Risk assessment tool for occupational health and safety

5.6.1 Step 1: Identify hazards

The site team, head of department Safety officer and researcher, identified hazards associated with operational processes. These were determined from inputs and outputs of the processes, tasks and equipment used. Apart from the brainstorming sessions, it was necessary to conduct a site inspection and observation. They also determined who could be harmed as well as determine if there were any existing controls.

5.6.2 Step 2: Evaluate the risks

The aim of this section was to decide for each significant hazard how much risk was involved after the existing precautions have been taken. When estimating likelihood, it was important that they considered how likely the hazard was to occur and to cause harm, not just how likely it was to occur. The findings enabled the establishment of how significant the hazards are and thus to prioritize any remedial actions required to control them. However, in this risk assessment a matrix was no longer used since literature shows that the qualitative approach has some limitations, such as it is not easy to incorporate the effects of risk reduction measures within the risk matrix, and neither method is easy to use to assess cumulative hazards, in particular at facilities where a large number of hazards exist (Phoya, 2012). The evaluation of risk usually involved the following steps.

5.6.3 Step 3 Estimate likelihood of each hazard

There was need to evaluate the risk associated with each process. Past experience, any relevant historical data on accidents and near misses and existing safety measures, were taken into account.

5.6.4 Estimate severity of each hazard

In this case, the human costs and adverse consequences of each hazard were considered. Also considered were the existing measures and any other factors (e. g. the circumstances under which the hazard takes place) that could mitigate the harm. Past incident records, written comments from the front line staff, customer complaints, safety audit reports, notes made in debriefing sessions and, post event reports were also used to provide the information needed to identify hazards. When estimating severity, the circumstances under which the hazard takes place were taken into account.

5.6.5 Hazard Evaluation criteria for safety and significance determination

Risk assessment and significance evaluation were identified and rated as stipulated in the next section in Table 5.9 to Table 5.12.

a. Severity

What will the severity or consequence of the hazard be?

Table 5.10: Hazard Evaluation criteria the severity or consequence

Score	Description	Definition
1	Insignificant	No Injury or First aid treatment required
2	Minor	Minor injuries or minor exposure requiring medical attention. No lost time
3	Moderate	Disabling injury or occupational disease. Lost time
4	Major	Number of disabilities or disabling disease
5	Catastrophic	Accidental fatality or fatalities OR serious occupational disease

b. Probability

How likely can the risk consequence occur?

Table 5.11: Hazard Evaluation criteria the Probability

Score	Description	Definition
1	Rare	Risk consequence will only occur in exceptional circumstances
2	Unlikely	Risk consequence is not likely to occur in a year
3	Possible	Risk consequence may occur within a year
4	Likely	Risk consequence could likely occur a few times per year
5	Almost certain	The event is almost certain to occur within a month

c. Exposure

The consideration is made concerning how many people are exposed to each hazard and for how long.

How much of the personnel are likely to be exposed?

Table 5.12: Hazard Evaluation criteria the Exposure

Score	Description	Definition
1	Minimal:	Only one employee is affected (Minimal time of exposure)
2	Restricted:	More than one employee may be affected
3	Local:	50% of employees may be affected
4	Widespread:	More than 50% of employees may be affected
5	Extensive:	100% of employees and general public may be affected

Once severity, probability and exposure were determined, the site team assigned a *pure risk rate* by summing up all three scores. Existing controls were considered to determine the residual risk, according to the formula below:

Residual risk= Pure risk- existing controls

Where Pure risk = Probability score + Severity score+ Exposure

Residual risk calculation

Pure risk = Severity + Probability + Exposure

Significance = Pure risk - Existing Controls

d. Existing Controls

What current controls or mitigation measures are in place?

Table 5.13: Hazard Evaluation criteria the existing controls

Score	Description
1	Those that protect and control the individual from exposure such as exposure to chemicals. E.g. Dust masks, safety shoes, hard hats etc.
2	Those that are procedural and include non-engineering controls to alter the way work is done as means of ensuring safe work practices. E.g. Procedures, work-instructions, medical checks ups, training and awareness etc.
3	Those that limit the hazard by using engineering means. Includes designs or modification to plants and equipment. E.g. Bunding, Insulating, Barricading, Filtration system)
4	Those that replace a component so to avoid the hazard. E.g. Substituting chemical X with another user friendly chemical
5	Those that completely eliminate the hazard from the work place, therefore eliminating the risk consequence.

5.6.6 Risk Control

In the occupational health and safety context, risk control is categorized according to hierarchy, often simply called the "risk control hierarchy." This hierarchy helps people to decide on which risk control to implement. Risk control options at the top of the hierarchy are preferred more than those at the bottom of the hierarchy. The preferred options are the most effective means of controlling risks because they can protect a larger number of people.

5.6.7 Establishing the risk level

Significant risks were those with a residual risk score between 10 and 15. The following table was used to suggest timeframes for managing the different priority occupational health and safety hazards and risks. Actual timeframes were agreed with team members.

Table 5.14: Time frames to action the risks

Total score	**Level of significance**	**Action**	**Time-frame**
1 – 5	Low level of Concern	Short Term	Monitor
6-9	Medium Level of Concern	Medium	Within 6 Months
10- 15	High Level of Concern	Immediate	Within 3 months

Occupational health and safety hazards were identified through the definition of activities/tasks inputs and outputs and recorded on the Hazards register, presented in Table 5.15 to 5.17 in the next session.

Table 5.15: Generation Department Hazard Register

Generation Department Hazard Register				Condition	Assessment													Legislation and other requirements
					Significance Evaluation													
										Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	**Normal/Abnormal/Emergency**	Severity	Probability	Exposure	**PURE RISK LEVEL**	**Existing Controls**	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	**CONTROL LEVEL**	**RESIDUAL RISK LEVEL**	**Significance(Low/Medium/ High)**	
Generation plant operation and maintenance	Oil level status report, Manpower Hydro-sets, Safe power generation Hydro-sets, , Rotating machinery Water usage, report book, electricity consumption, checklist	Slippery floor due to oil leakages	Head and body injuries due to slippery floor	A	3	2	2	7	Oil spill cleaned using oil spill kit.				X		2	5	L	The Occupational safety and Health Act of 2001
		Exposure to live wires	Electrocution, electric shock	A	5	2	1	8	SECIES used				X		2	6	M	The Occupational Safety and Health Act of 2001, section 8, Section 9 and section 11
		Exposure to computer monitor light	Eyesight straining	A	2	1	2	5	No controls in place						0	5	L	The Occupational safety and Health Act of 2001

Table 5.16 Distribution Department Hazard Register

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation													
										Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
Planned and Reactive Maintenance Excavation and trenching (digging) Pole mounting, Bush clearing Use of ladder and other tools/ equipment Replacement of faulty transformers Use of lifting equipment (cranes) Pole erection, climbing and stringing Testing live circuit	Man power Protective clothing Tool-kit Transport Location Route Tillage Repaired line Scrapped material Accidental spills	Exposure to snake bites	Poisoning of persons, fatality, bodily injuries	A	5	1	1	7	General Safety awareness done					x	1	6	M	Occupational Safety and Health Ac of 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation													
										Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
	Electric and magnetic fields	Fatigue: due to working extra hour when required, creating a higher risk of harm when leaving work premises and driving	Vehicle accidents, poor workmanship,	E	5	1	2	8	Controls include leave is managed,				X		2	6	M	The Occupational Safety and Health Act, of 2001, section 8. Section 9 and section 11

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Fatigue: due to working extra hour when required, creating a higher risk of harm when leaving work premises and driving	Vehicle accidents, poor workmanship,	E	5	1	2	8	Controls include leave is managed,				X		2	6	M	Occupational Safety and Health Act, 2001, section 8. Section 9. And section 11

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Working under live circuit	Electrocution, electric shock, damage to equipment	N	5	3	1	9	Procedures in place (ORVSH -working instruction) SECIES				X		2	7	M	The Factories, Machinery and Construction Works Regulations of 1974, Part IV
		Exposure to bad weather (hailstorm, wind, thunderstorms and lighting)	Vehicle accidents, property damage	E	3	3	5	11	SECIES used			X			3	8	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11.

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Use of inappropriate hand tools	Tendinitis of the hands, wrists and elbows Carpal tunnel syndrome Falls and body injuries	N	3	3	2	8	Procedures in place (ORVSH - working instruction) SECIES				X		2	6	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11
		Working on bad terrain	Bodily injuries (fractures), vehicles accidents,	N	5	4	2	11	None, Except wearing appropriate PPE issued					x	1	10	H	The Occupational Safety and Health Act of 2001, section 8. Section 9. and

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
			kidney damage, exhaustion, stress						and used									section 11
		Working at night hours	Injuries from attacks, snake and insect bites, eye strain	E	5	1	2	8	None					x	1	7	M	The Occupational Safety and Health Act of 2001, Section 8, 9 and 11
		Working at heights or elevated positions (ladders)	Falls (limbs fracture), exposure to insect bites, fatality	N	4	3	2	9	SECIES, Maintenance procedure				X		2	7	M	The Factories, Machinery and Construction Works Regulations of 1974, Part VII (Reg. 123)

Distribution Department Hazard Register				Condition	Assessment														Legislation and other requirements
					Significance Evaluation					Controls (x)									
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)		
		Falling objects and line components	Head injuries, fatalities,	A	3	4	2	9	None, Except wearing appropriate PPE					x	1	8	M		The Occupational Safety and Health Act of 2001, section 8. 9. and section 11
		Extreme temperatures and exposure to High UV rays	Eyes straining, skin infections, headaches	N	3	3	3	9	None, Except wearing appropriate PPE					x	1	8	M		The Occupational Safety and Health Act of 2001, section 8. Section 9. And section 11

Distribution Department Hazard Register				Condition	Assessment: Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Use of un-trained contractors	Unsafe practices, Unsafe working environment, High Risk of injury to staff , Risk of injury to contractors ,	N	5	3	2	10	SECIES used				X		2	8	M	The Occupational Safety and Health Act of 2001, section 8. section 9. and section 11
		Aged/ Obsolete electrical equipment	Electrocution, electric shock, Arcing , property damage	A	3	3	3	9	Maintenance plan				X		2	7	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register				Condition	Assessment													Legislation and other requirements
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
Earthing		Use of Alcohol and Drugs	Violence, Personal injuries, vehicle accidents, Low productivity, Absenteeism	A	5	2	2	9	Safety procedures, Disciplinary Code				X		2	7	M	SEC Disciplinary Code
		Poorly maintained mini substations	Electrocution, snake bites	A	5	3	1	9	Maintenance plan			X			3	6	M	The Factories, Machinery and Construction Works Regulation of 1974, Section 31

Distribution Department Hazard Register				Condition	Assessment – Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
New projects execution and connection of new customers Excavation of trenches Pole mounting Use of ladders and (cranes) Construction of new lines Surveying of new lines of new lines	Electric and magnetic fields (EMF) Disturbed flora and	Use of damaged equipment and tools	Accidents from tools, instruments and equipment that are poorly maintained, inappropriately used	A	3	3	2	8	None except for wearing appropriate PPE					X	1	7		The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register				Condition	Assessment													Legislation and other requirements
					Significance Evaluation					Controls (x)								
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
	Scraped material Contaminated scrap Spillage of oils Electromagnetic waves Manpower PPE	Fatigue due to working extra hours when required	Vehicle accidents and poor workmanship	E	3	3	3	9	Controls including leave management				X		2	7		The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register				Condition	Assessment													Legislation and other requirements
					Significance Evaluation													
										Controls (x)								
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
				A	3	3	2	8	None, Except wearing appropriate PPE					x	1	7	M	
		Existence of open holes	Livestock injuries or fractures, persons limbs	N	3	3	5	11	Procedures working, instruction SECIES				X		2	9	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
			and fractures						place									section 13
		Exposure to bad weather (hailstorm, wind, thunderstorms and lighting)	Vehicle accidents, property damage	E	3	3	5	11	SECIES in place			X			3	8	M	The Occupational Safety and Health Act, 2001, section 8. Section 9. And section 13
		Use of inappropriate hand tools	Bodily injuries, damage to the equipment	N	3	3	2	8	Procedures and SECIES used				X		2	6	M	The Occupational Safety and Health Act, 2001, section 8.

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Use of non-calibrated measuring or testing instruments	Electric shock, damage of equipment, use of wrong equipment	A	5	2	2	9	SECIES in place and used				X		2	7	M	The Factories, Machinery and Construction Works Regulations, 1974, Part IV
		Inappropriate P.P.E. use	Bodily injuries, infections (skin, eyes)	A	3	3	3	9	SECIES				X		2	7	M	The Occupational Safety and Health Act of 2001, section 8. and Section 9. section 13
		Working on bad terrain	Bodily injuries (fractures), vehicles	N	5	4	2	11	None, Except wearing appropriate					x	1	10	H	The Occupational Safety and Health Act of 2001, section

Distribution Department Hazard Register				Condition	Assessment													Legislation and other requirements
					Significance Evaluation					Controls (x)								
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
			accidents,						PPE									8. Section 9. and 13
		Working at heights or elevated positions	Falls (limbs fracture),	N	4	3	2	9	SECIES, Maintenance procedure				X		2	7	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 13
		Falling objects and line components	head injuries, fatalities,	A	3	4	2	9	None, Except wearing PPE					x	1	8	M	The Occupational Safety and Health Act of 2001, Section 9

Distribution Department Hazard Register				Condition	Assessment – Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Extreme temperatures and exposure to High UV rays	Eyes straining, skin infections, headaches	N	3	3	3	9	None, Except wearing appropriate PPE					x	1	8	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 13
		Use of inappropriate lifting equipment (beyond stipulated range carrying capacity)	Head injuries, fatalities, damage to property	A	5	2	2	9	SECIES, Maintenance procedure used				X		2	7	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 13

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
Transportation of material, human and other resources to working sites -Site clearing -Loading and offloading of materials at the working site Driving of vehicles	Delivery of material Man power Protective clothing Tool-kit Transport Route	Exposure to bad weather (hailstorm, wind, thunderstorms and lighting) and bad roads	Vehicle accidents, property damage	E	5	4	4	13	PPE used and defensive driving				X		2	11	H	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11
		Use of defective lifting equipment	head injuries, fatalities, damage to property	A	5	2	2	9	SECIES, Maintenance procedure in place and used				X		2	7	M	The Occupational Safety and Health Act of 2001, Section 9 and 11.

Distribution Department Hazard Register

Activity	**Outputs**	**Hazard**	**Risk**	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
Packing , stacking and storage of material at depot premises Site clearing and use of lifting equipment		Fatigue: due to working extra hour when required, creating a higher risk of harm when driving	Vehicle accidents, poor workmanship,	E	3	3	3	9	Controls include leave management				X		2	7	M	The Occupational Safety and Health Act, 2001, section 8. Section 9. And section 11
		Use of untrained personnel	Bodily injuries (fractures), vehicles accidents,	N	3	3	2	8	On the job training				x		2	6	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation					Controls (x)								Legislation and other requirements
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
		Lack of appropriate off-loading equipment (e.g. poles, transformers, kiosk)	Accidental damage of material and equipment, grievous body harm	N	3	3	2	8	None, Except wearing appropriate PPE					x	1	7	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11
		Use of defective lifting equipment	Accidental damage of material, Fatality (crashing from material load)	N	3	2	2	7	Trained operators used				X		2	5	L	The Occupational Safety and Health Act, 2001, section 8. Section 9. And section 11

Distribution Department Hazard Register

				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		New products, equipment and tools	Introducing new or uncontrolled hazards into the workplace. Introducing new and/or uncontrolled wastes	A	3	2	2	7	Procurement policy in place				X		2	5	L	The Occupational Safety and Health Act, 2001, section 8. Section 9. And section 11
		Manual handling of material	Lower back pain Cuts Injuries	N	2	2	2	6	Training on material handling				X		2	4	L	The Factories, Machinery, Construction Works Regulations 1974

Distribution Department Hazard Register				Condition	Assessment													Legislation and other requirements
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
Storage of fuel and fuel dispensation Existence of unused underground fuel tank Vehicle fueling from above ground fuel tank	Refueled vehicle Fuel tanks Fuel dispensers	Fire	Asphyxiation, bodily harm, fatalities, property damages , time bomb	E	5	2	2	9	Encased fuel tank and signage			X			3	6	M	The Factories, Machinery and Construction Works, Regulations of 1974, Part VII
		Exposure to fumes	Respiratory complications,	N	3	2	2	7	None					x	1	6	M	The Occupational Health and Safety Act of 2001

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
	Man power Protective clothing Tool-kit (GPS, Measuring wheel) Transport Location/Route	Lone working	Unreported incidents (fatalities, injuries), animal attacks, robbery attack	N	3	5	1	9	SECIES, Maintenance procedure				X		2	7	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11
		Exposure to snake bites	Fatality, injuries, allergy attack	A	5	1	1	7	None					x	1	6	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register

				Condition	Assessment / Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Exposure to extreme or high UV rays	Eyes straining /damage, skin infections, headaches, dehydration	N	3	4	2	9	None					x	1	8	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11
		Confrontation with aggressive customers	Physical attacks (injuries), Work Stress	N	2	1	2	5	On-the-job training of personnel				X		2	3	L	The Occupational Safety and Health Act, 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Office congestion	Airborne infection transmission, All staff could experience general discomfort.	A	3	1	2	6	Engineering- with adequate ventilation			X			3	3	L	The Building Standard Regulations of 1969, PART IV
		Inappropriate ambient temperature	Some staff could experience general discomfort.	A	2	1	2	5	Engineering- with adequate ventilation			X			3	2	L	The Building Standard Regulations of, 1969, PART IV

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Manual handling of material,(paper, equipment)	Staff in offices may suffer injury from material falling from overloaded or collapsing shelves or items stored at height.	N	3	1	2	6	On-the-job training of personnel				X		2	4	L	The Factories, Machinery and Construction Works Regulations of 1974, Part VIII (reg.149)
		Slips, trips and falls (untidy cabling, general	Staff and visitors may suffer sprains	N	4	4	2	10	None					x	1	9	M	The Occupational Safety and Health Act of 2001, section

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		poor housekeeping)	or a fracture if they trip over trailing cables/rubbish or slips on spillages.															8. Section 9. and section 11
		Use of external doors with glass paneling, due to slamming against door jamb on windy days, invisibility	Potential for glass cuts	N	1	4	1	6	Visible stickers				X		2	4	L	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation													
										Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Inhalation of fumes from photocopiers	Acute Respiratory infections	N	2	4	2	8	Maintenance by suppliers				X		2	6	M	The Building Standard Regulations, 1969, PART IV
		Poor wiring set up	Electrocution, tripping, electric shock	A	5	2	1	8	SECIES used				X		2	6	M	The Occupational Safety and Health Act of 2001, section 8. Section 9 and section 11
		Display screen equipment (regular computer use)	Eye Discomfort, Pain and Injury (DPI)	N	3	3	4	10	On-the-job training of personnel				X		2	8	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and

Distribution Department Hazard Register				Condition	Assessment														
					Significance Evaluation					Controls (x)									
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Poor ergonomic set-up e.g. wrong seating and use of worn out furniture	Staff in offices may suffer occupational injury from sitting on hard surfaces(unsupported benches), wrong height, falling, injury from sharp edges	N	3	3	2	8	None					x	1	7	M	The Building Standard Regulations, 1969, PART IV

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Open drains (trench)	Falling and body injuries	A	3	2	1	6	Depot maintenance contractor engaged				X		2	4	L	The Occupational Safety and Health Act, 2001, section 8. Section 9. and section 11
		Exposure to Robbers	Injuries from attacks	A	5	1	2	8	Security personnel in place				X		2	6	M	The Occupational Safety and Health Act, 2001, section 8. Section 9. and section 11

Assessment — Significance Evaluation — Controls (x)

Distribution Department Hazard Register				Condition	Assessment														Legislation and other requirements
					Significance Evaluation					Controls (x)									
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)		
	Stored material Stored chemicals Stored hydraulic oils Storage area (Shelter) Man power Transformer shed Pole yard	Falling material, toppling of furniture (poor stacking)	Staff in offices/storeroom may suffer injury from material falling from overloaded or collapsing shelves or items stored at height.	A	2	1	2	5	On-the-job training of personnel				X		2	3	L		The Occupational Health and Safety Act of 2001, Section 11.

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment – Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
		Manual handling of material	Lower back pain Cuts Injuries	N	3	3	2	8	PPE issued and used					x	1	7	M	The Factories, Machinery and Construction Works Regulations of 1974, Part VIII (reg.149)
		Use of inexperienced personnel	Hand injuries, skin allergies, inhalation	N	3	3	2	8	Induction done				X		2	6	M	The Occupational Health and Safety Act of 2001, Section 11.
		Exposure to fire	Asphyxiation, bodily harm, fatalities, property	E	5	2	3	10	Emergency preparedness plan in place				X		2	8	M	The Occupational Health and Safety Act of 2001, Section 11.

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Assessment / Significance Evaluation: Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	Controls (x): (5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
			damages															
		Inadequate warning signage	Injuries, fatality	A	5	2	5	12	Sites walk about done				X		2	10	H	Occupational Health and Safety Act, 2001
		Use of Alcohol and Drugs	Violence, Personal injuries, vehicle accidents, Low productivity, Absenteeism	A	5	2	2	9	Safety procedures, Disciplinary Code in place and used				X		2	7	M	SEC Disciplinary Code

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
					Assessment													
					Significance Evaluation					Controls (x)								
	Parked heavy duty vehicles Parked light duty vehicles Authorized drivers Parking lanes	Fumes, dust exposure	Respiratory infections	A	3	5	3	11	None					x	1	10	H	The Factories, Machinery and Construction Works, Regulations of 1974, Part VIII
		Exposure to corrosive bleach and strong detergents	Hand injuries, skin allergies	A	1	1	1	3	MSDS Reference				X		2	1	L	The Occupational Health and Safety Act of 2000
		Congestion and shortage of parking space	Accidents	N	2	3	2	7	Security personnel and signage					x	2	5	L	The Occupational Health and Safety Act of 2000

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
	Improved house keeping aesthetics chemicals pesticides	Inadequate warning signage	Injuries, fatality	A	5	2	5	12	Sites walk about done				X		2	10	H	The Occupational Health and Safety Act of 2001
		Open drains (trench)	Injuries, fractures, vehicle damages	N	3	3	1	7	Depot maintaining contractor engaged					x	1	6	M	The Occupational Health and Safety Act of 2000
		Poorly maintained air compressors	Injury, explosion	A	3	3	2	8	Air compressor inspection done				X		2	6	M	The Factories, Machinery and Construction Works, Regulations of 1974, Part VI

Distribution Department Hazard Register				Condition	Assessment														
					Significance Evaluation														
										Controls (x)									
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Smoking cigarettes	Lung and throat cancer, Unhealthy working environment	N	3	2	2	7	Designated smoking area in place				X		1	6	M	The Occupational Health and Safety Act of 2001, Section 11.
		Fire hazard	Asphyxiation, bodily harm, fatalities, property damages	E	5	2	3	10	Emergency plan in place				X		2	8	M	The Factories, Machinery and Construction Works, Regulations of 1974, Part VII

Distribution Department Hazard Register				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
	Transport : Motorcycle and vehicles Man power Tools and equipment Inspected meter Data disconnections, PPE reconnections	Exposure to (wasp, bees)	Skin allergies	A	2	4	3	9	PPE issued and used					x	1	8	M	The Occupational Health and Safety Act of 2001, Section 11.
		Exposure to assaults Confrontation with aggressive persons/animals	Fatality, injuries, Grievous body harm	A	2	2	1	5	Pre-paid and smart metering			X			3	2	L	The Occupational Health and Safety Act of 2001, Section 11.
		Exposure to snake bites	Fatality, injuries	A	3	1	3	7	None, Except wearing right PPE					x	1	6	M	The Occupational Health and Safety Act of 2001, Section 11.

Distribution Department Hazard Register

Activity	Outputs	Hazard	Risk	Condition: Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	Legislation and other requirements
					Assessment													
					Significance Evaluation					Controls (x)								
		Exposure to dog bites	Rabies, fatality, injuries	A	5	1	1	7	Training on dog management done				X		2	5	L	The Occupational Health and Safety Act of 2001, Section 11.
		Lone working	Fatalities, injuries, animal attacks, robbery attack	N	3	5	1	9	SECIES, Maintenance procedure in place				X		2	7	M	The Occupational Safety and Health Act of 2001, section 8. Section 9. and section 11
		Inappropriate PPE	Severe injury	A	4	3	1	8	Company rules and procedure				X		1	7	M	SEC Disciplinary Code

Distribution Department Hazard Register

				Condition	Assessment													
					Significance Evaluation					Controls (x)								
Activity	**Outputs**	**Hazard**	**Risk**	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	**Legislation and other requirements**
		Driving in bad weather Condition	Vehicle accidents, property damage	A	5	2	2	9	Issued based risk assessment done				X		2	7	M	Required in SECIES
	Controlled speed at entrance Secured property Signage Boom gate Man power Speed controls	Working at night hours	Grievous body harm Fatalities Property damage Injuries, attacks,	N	5	2	2	9	Communication-on devices and emergency procedures				X		2	7	M	The Occupational Health and Safety Act of 2001, Section 11.

Distribution Department Hazard Register				Condition	Assessment													Legislation and other requirements
					Significance Evaluation													
										Controls (x)								
Activity	Outputs	Hazard	Risk	Normal/Abnormal/ Emergency	Severity	Probability	Exposure	PURE RISK LEVEL	Existing Controls	(5) Elimination/Termination	(4) Substitution	(3) Engineering	(2) Administrative	(1) PPE	Existing control	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
		Prolonged exposure to extreme weather condition especially cold	Occupational diseases pneumonia	N	3	3	2	8	Outsourced services contracts in place				X		2	6	M	The Occupational Health and Safety Act, 2001, Section 11.
		Over speeding vehicles along entrance/exit point	Vehicle accidents	N	4	3	2	9	Signage in place				X		2	7	M	The Occupational Health and Safety Act, 2001, Section 11.

Table 5.17: Transmission Department Hazard Register

TRANSMISSION DEPARTMENT HAZARD REGISTER					Condition														Legislation and other requirements
						Assessment													
						Significance Evaluation													
No.	Work Activity	Inputs and Outputs	Hazard	Risk	Normal/Abnormal/ Emergency (N/A/E)	Severity	Probability	Exposure	PURE RISK LEVEL	Existing control	(5) Elimination /Termination	(4) Substitution	(3)Engineering	(2) Administration	(1) PPE	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
1	Line Patrol	Vehicle Manpower Radio (car/portable radio) Binoculars Bush knives, hammers Stationery	Exposure to snake, dogs and allergens	Body injuries and fatalities, poisoning, dog bites and or rabies and allergic reactions	N	2	1	5	8	Training ,PPE issued and used HIRA conducted				x	x	2	6	L	The Occupational Safety and Health Act of 2001

TRANSMISSION DEPARTMENT HAZARD REGISTER					Condition															Legislation and other requirements
						Assessment														
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Hazard	Risk	Normal/Abnormal/ Emergency (N/A/E)	Severity	Probability	Exposure	PURE RISK LEVEL	Existing control	(5) Elimination /Termination	(4) Substitution	(3)Engineering	(2) Administration	(1) PPE	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
		(files, paper, pens) Computer, printers	Working at heights	Falling resulting to body injuries, fatalities	N	5	3	2	10	Training, PPE and work instruction provided and used				x	x	2	8	M	The Factories, Machinery and Construction Works Regulations of 1974

TRANSMISSION DEPARTMENT HAZARD REGISTER					Condition	Assessment													Legislation and other requirements
						Significance Evaluation													
No.	Work Activity	Inputs and Outputs	Hazard	Risk	Normal/Abnormal/ Emergency (N/A/E)	Severity	Probability	Exposure	PURE RISK LEVEL	Existing control	(5) Elimination /Termination	(4) Substitution	(3)Engineering	(2) Administration	(1) PPE	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
2	Bush clearing, Line construction and maintenance	Vehicles Maintenance tools (picks, shovels, crow bars, bush knives) Lifting machines and tirfors Aluminum ladders	Exposure to wildlife , thugs	Body injuries, fatality or poisoning due to attacks or bites from wildlife	N	2	1	2	5	PPE, Awareness sessions provided				x	x	2	3	L	The Occupational Health and Safety Act of 2001
		Creosote treated poles	Exposure to creosote treated poles	Skin infections or irritations	N	2	3	2	7	PPE issued and used					x	1	6	M	The Occupational Health and Safety Act of

TRANSMISSION DEPARTMENT HAZARD REGISTER					Condition	Assessment														Legislation and other requirements
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Hazard	Risk	Normal/Abnormal/ Emergency (N/A/E)	Severity	Probability	Exposure	PURE RISK LEVEL	Existing control	(5) Elimination /Termination	(4) Substitution	(3)Engineering	(2) Administration	(1) PPE	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
				due to exposure to creosote treated poles															2001
			Use of vehicles in bad roads / at high speeds	Fatality and body injury due to accidents	A	4	3	2	10	Defensive driving lessons provided and disciplinary procedures in place				x		2	8	M	The Occupational Health and Safety Act of 2001
			Fire outbreak	Body injuries, Burns and equipment damage due to	N	5	1	2	8	Fire extinguishers in place Safety talks and emergency preparedness plans				x		2	6	M	The Occupational Health and Safety Act of 2001

TRANSMISSION DEPARTMENT HAZARD REGISTER					Condition	Assessment													
						Significance Evaluation													Legislation and other requirements
No.	Work Activity	Inputs and Outputs	Hazard	Risk	Normal/Abnormal/ Emergency (N/A/E)	Severity	Probability	Exposure	PURE RISK LEVEL	Existing control	(5) Elimination /Termination	(4) Substitution	(3)Engineering	(2) Administration	(1) PPE	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
				electrical faults and fire exposure															
4	Battery charger installation	Batteries	Fume production battery acid spillage and	Skins irritations, burns fatalities	N	3	1	2	6	Process procedures, first aid kits and PPE in place				x		2	4	L	The Occupational Health and Safety Act of 2001
5	HV Yard Maintenance	Manpower Equipment (brush cutter) Picks ,	Use of picks and slashers	Body injuries	N	2	2	3	7	PPE and procedures in place, Awareness sessions conducted				x		2	5	L	The Occupational Health and Safety Act of 2001

TRANSMISSION DEPARTMENT HAZARD REGISTER					Condition	Assessment													Legislation and other requirements
						Significance Evaluation													
No.	Work Activity	Inputs and Outputs	Hazard	Risk	Normal/Abnormal/ Emergency (N/A/E)	Severity	Probability	Exposure	PURE RISK LEVEL	Existing control	(5) Elimination /Termination	(4) Substitution	(3)Engineering	(2) Administration	(1) PPE	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)	
		slashers PPE killer Bulbs 250 (mercury vapor , LEDs, lamps, CFLs)	Mercury fumes from broken bulbs	Poisoning due to inhalation of mercury fumes or bodily injuries due to broken bulb glass	N	2	1	1	4	PPE and procedures in place, Awareness sessions conducted				x		2	2	L	The Occupational Health and Safety Act of 2001
			Extreme weather exposure	Dehydration, hyperthermia Property damage to vehicle	N	2	3	2	7	Awareness sessions and PPE				x		2	5	L	The Occupational Health and Safety Act of 2001

TRANSMISSION DEPARTMENT HAZARD REGISTER					Condition	Assessment														Legislation and other requirements
						Significance Evaluation														
No.	Work Activity	Inputs and Outputs	Hazard	Risk	Normal/Abnormal/ Emergency (N/A/E)	Severity	Probability	Exposure	PURE RISK LEVEL	Existing control	(5) Elimination /Termination	(4) Substitution	(3)Engineering	(2) Administration	(1) PPE	Existing Controls/ Mitigation measures	RESIDUAL RISK LEVEL	Significance(Low/Medium/High)		
7	Meter installation on 400V Meter testing on site Meter testing in lab Reprogramming of meters Automated meter reading installation	Manpower Testing instrument benches Injector Multi-meter Portable working standard /Desk Meter Procedure	Exposure to live chambers	Electrocution and fatalities	N	5	1	2	8	PPE, HIRA SEISIS and procedures in place and used			X			3	5	L		The Occupational Health and Safety Act of 2001

5.7 Conclusion

The main objective of this chapter was to present the developed tool for assessing risks in the electricity sector mainly in the operations department (generation, distribution and transmission of electricity). This tool was developed for the identification and prioritization of risks emanating from hazards and aspects and used expert knowledge, opinions, and experiences their different processes.

Risk assessments conducted in isolation to a management system structure have major limitations to an organisation. Therefore, risk assessment must be conducted within a management system with appropriate controls identified and implemented, and then its benefits become evident. Hence, this research provides a procedural systematic sequence to identify, assess, evaluate and control risks in risk assessment programmes. Two management systems (ISO 14001 (2004) and OHSAS 18001 (2007) were used as they can be easily integrated due their similarities identifying intangible risks; occupational, health, safety and environmental risks. This has not been a focus on most research in the electricity sector as more emphasis was on financial risk.

The overall environmental risk assessment process involved risk analysis and evaluation, which took into account factors contributing to the existence of risk. The risk analysis was used to define the process of identifying and measuring potential impact of the risk. Process mapping was used for the identification of the hazards and aspects. This process allowed that all risks which were emanating from significant activities or processes at all levels from electricity generation, transmission to distribution be identified and their business impacts were evaluated.
In order to ensure that there was a comprehensive coverage of all hazards and aspects associated with each process, a team approach was used. The researcher and line management team members knew and understand operational risks better and were therefore better placed to provide resources in terms of competent personnel and in providing measures to address risks. It was imperative to involve a representative of the employees who carry out the task being assessed, as they knew how the job is actually done, had experience of abnormal, as well as normal

conditions and understood the scope for dangerous shortcuts. These employees of various skills, expertise and experience were engaged in brainstorming sessions for the risk assessment process. For instance the distribution team consisted of an electrical engineer, senior electrical technician, electrician, lines man, grounds man and branch superintendent, who was in charge of the depots. Members of the safety and environment department were also part of these teams. The researcher was also part of these teams.

The risk analysis and estimation for this research involved the consideration of the risk source. The process employed quantitative and qualitative methods of risk estimation. For the quantitative methods, risk criteria numerical values were assigned and were directly aligned to a measurable quality of a hazard or aspect. For instance rating a severity as 1, if the measured risk is minimal or a rating of 5 when it is catastrophic. The quantitative assessments did not take into account factors which could be scientific or measurable. These assessments relied heavily on the employees experience and viewpoints hence it was necessary to ensure that competent experienced employees formed part of the teams that conducted risk assessments. Secondly when assigning values for both risks and impacts, consensus was used or cross-sectional views of teams were sought to assign a value. This aspect of the research ensured that subjectivity was addressed.

The criteria used to estimate the risks included as severity, probability and consequence in the case of occupational health and safety. For the environment, the criteria used to rank and prioritise the risk included legislation, concerns from affected parties and frequency. The sum of all the parameters that were rated then constituted the pure risks. The control measures which were in place to minimise risks were identified. The risk control hierarchy was used to rate the existing controls. The controls according to the hierarchy are as follows from the best to the least effective; elimination, substitution, engineering, administrative and personal protective equipment. The score given to existing controls was subtracted from the pure risk to determine the residual risk.

This methodology improved greatly as it now brings in the aspect of residual risk which was not considered in the methodology used in chapter 4. The residual risk which is basically the risk that needs to be controlled further after the application of the existing controls to ensure that it is within acceptable risk levels. When residual risk was rated as high, it was regarded as a key risk indicator. Key risk indicators required management focus so that proactive action could be taken to prevent the risk from occurring. The residual risk also determined the time frame in which the risk had to be controlled. The risks were then prioritized and mitigation or strategies to control risks further were developed.

The medium risks had to be addressed within 6 months whilst the high risks needed to be addressed within 3 months and required additional control measures or improvements in the effectiveness of the existing controls. The low risks were to be monitored to ensure that they remain low and not ignored. Programmes were therefore developed and timeframes and resources were assigned for the implementation of the control measures. This will enhance effective management of risks in the operations department and is informative in decision making when it comes to risk management in an organisation. The next chapter discusses the findings of the study.

6 CHAPTER 6: FINDINGS, ANALYSIS AND DISCUSSION

6.1 Introduction

This chapter presents the analysis, discussion and findings, on the new model to assess the environmental, occupational health and safety risk associated with the electricity industry in Swaziland.

6.2 Questionnaire survey results

The questionnaires were administered to managers and technicians in the operations department (transmission, distribution and generation and support services of SEC). The results are discussed in the following sections.

6.3 General information

Figure 6.1 indicates of the 54 employees interviewed, 70% were males and the rest were females. The respondents had ages ranging from 20 to 50 and had been engaged in the organisation for a period of up to 40 years. This indicates that the respondents were mostly experienced in the electrical fields. The study also revealed that that the older generation above 50 years, is no longer available within the operations department.

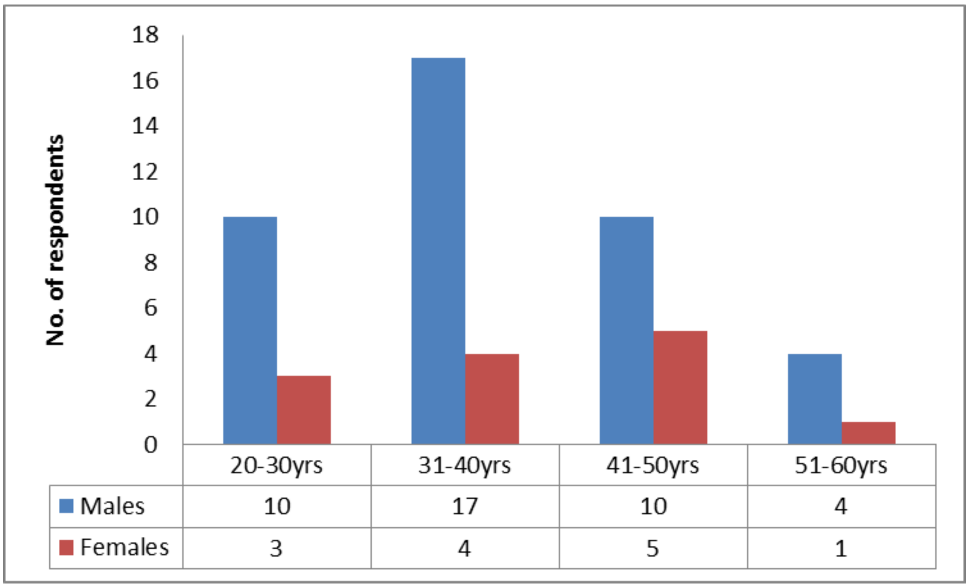


Figure 6.1: Gender and age representation of respondents in the study

6.4 Educational background of respondents

The study indicated that almost all the respondents had at least Form 5, a diploma and some had degrees and a few had post graduate degrees. The results indicated that since an electrical operation is a specialized field most of the operational employees have adequate qualifications which improve on their competency.

The highest qualification from the respondents was Post graduate diploma or Masters Degrees (Figure 6.2). However, it was observed that 51% of the respondents have not been schooled / exposed to principles of Occupational health and safety as well as environment management (Figure 6.3). They responded that they have been briefly made aware of the two systems ISO 14001 (2004) and OHSAS 18001 (2007).

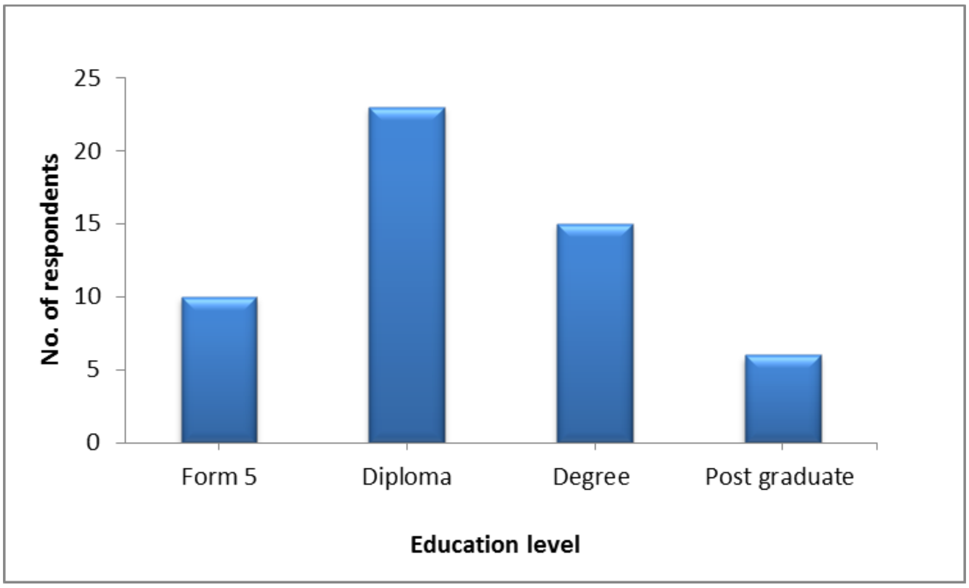


Figure 6.2: Educational level of respondents involved in this study

6.5 Work experience of respondents within SEC

With regards to work experience, almost 50% of the respondents have less than five years in the company (Figure 6.3). The other half has experience that varies between 6 and 15 years. There are a few of the respondents who worked over 20 years.

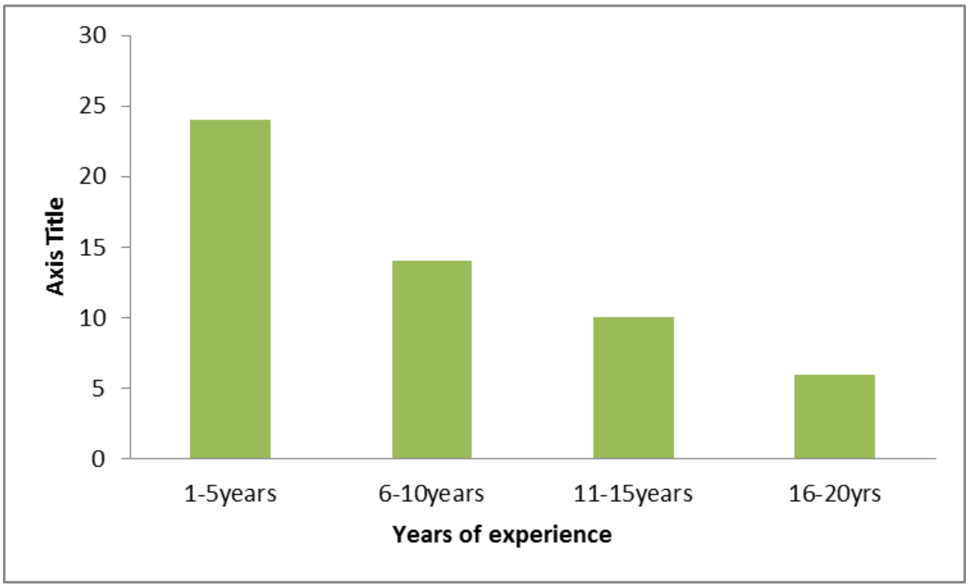


Figure 6.3: Respondents work experience

6.6 Exposure to SHERQ training

Figure 6.4 indicates that (49%) of the respondents have been exposed to Safety Health Quality and environmental training. However, a majority which is 51% of respondents have not been exposed to some of the SHERQ training. The result shows that there is a gap in the level of understanding from managers, supervisors and ordinary employees that need to be closed by means of education and training on occupational health and safety and environmental issues. Safety education will help employees identify problems and solve them directly when they occur, according to the bottom-to-top principle (Zweetsloot, 2003).

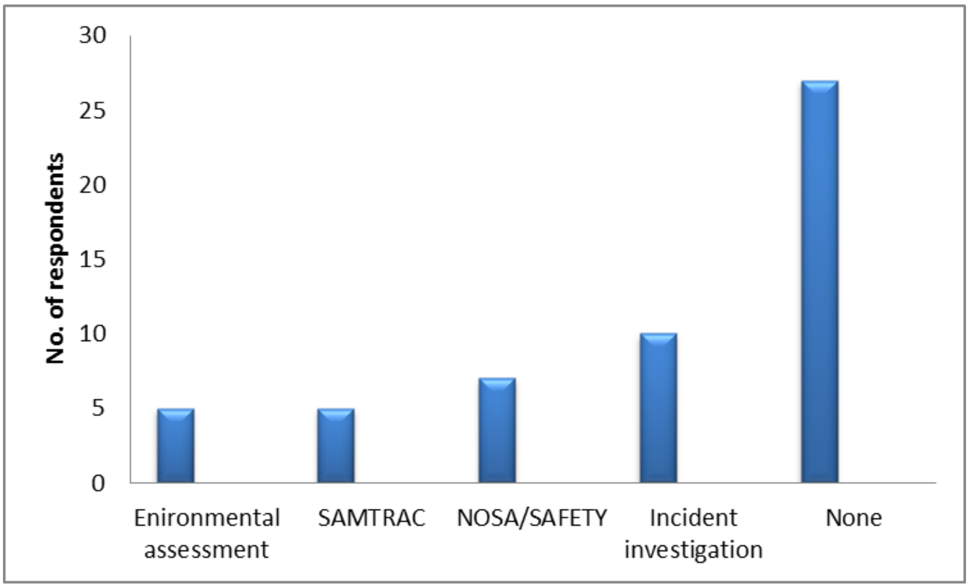


Figure 6.4: Number of respondents exposed to different SHERQ training

6.7 Respondents per division

Figure 6.5 below indicates that most of the respondents were from the operations department. The support services had 15% respondents; this can be attributed to the fact that the questionnaire and methodology was tested within the SHERQ department which is part of the Support services divisions.

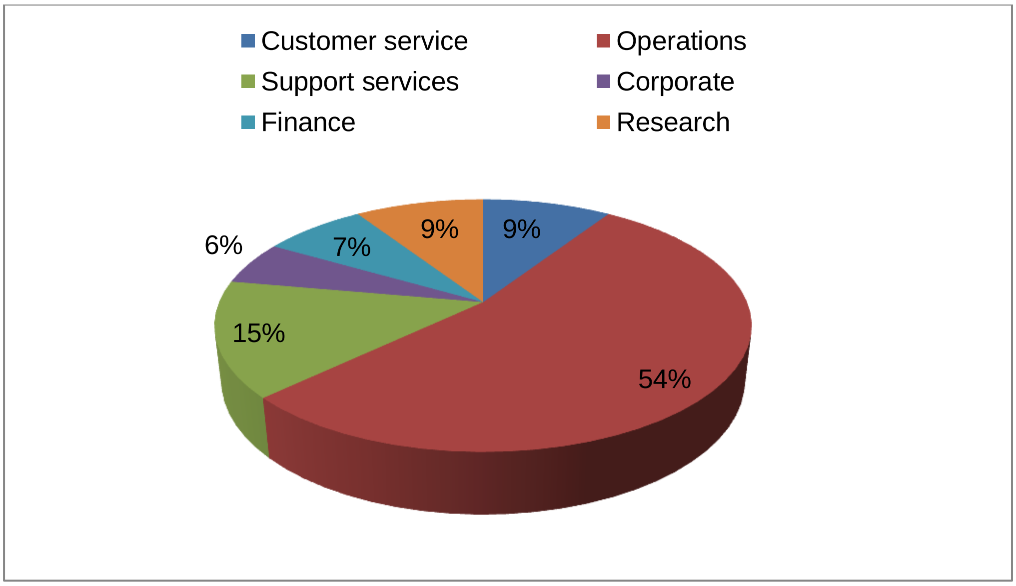


Figure 6.5: Percentage respondents per division of the Swaziland Electricity Company

6.8 Summary of risks associated with electricity operational processes

Tables 6.1 and 6.2 present a summary of the results of environmental risks (environment, occupational health and safety risks) in the operations within the electricity sector in Swaziland. The results from this study indicate that the environmental aspects include disposal of waste, fuel leaks, and spillages of battery solution and improper storage of waste. The hazards were mainly; road hazards, explosions/fire, working under adverse weather conditions, exposure to live wires and exposure to natural elements such as snakes.

Table 6.1: Summary of risks which were identified from the questionnaires – Health and Safety Risk Assessment Findings

Activity	Hazard	Risk
Line construction and maintenance	Exposure to live wires	Electrocution, fatality
Hydropower generation	Exposure to noise from generators	Occupational noise-induced hearing loss
Generator Maintenance	Slipping and falling	Body injuries
	Exposure to dust particles.	Chest and lung infections, eye infections
	Using a defective and poor positioned step ladder	Body injuries
	Equipment lifting (turbine and man hole covers),	Body strains and injuries
	Exposure to incandescent powder and or mercury.	Injuries, eye and lung infections
Worker transportation	Using vehicles that are not road worthy	Body injuries, fatalities
	Driving vehicles at high speeds in bad road conditions	Body injuries, fatalities
Infrastructure maintenance	Falls of ground	Body injuries, fatalities
	Falling objects	Body injuries,
	Handling of tools	Body injuries,
	Fires	Burns
	Slippery canal	Drowning
	Materials are scattered everywhere haphazardly, the floor is wet or greasy, inappropriate footwear	Slips and falls
	contact with a live electrical conductor	Electrocution, Burns,
	using poorly maintained electrical equipment,	
	Working near overhead High tension lines or domestic electricity supplies, contact with underground power cables without appropriate safety gear.	

	Manual Handling	Back injuries and emasculatory disorders, sciatica, hernias and slipped discs
Using chemicals (paints, varnishes, pesticides)	Exposure to chemicals through breathing ingestion and absorption through the eyes or skin	Headaches, eye irritation, dizziness, sleepiness, likelihood of cancer

Table 6.2: Summary of risks identified from the questionnaires- Environment Risk Assessment findings

Activity	Aspect	Impact
Line construction and maintenance	Removal of vegetation during site establishment	Soil erosion and Loss of biodiversity
	Spillage of transformer oil	Soil contamination by oil
	Spillage of oil from oil coolers	Water pollution
Hydropower generation	Use of water	Water resource depletion
Generator Maintenance	Disposal of oil contaminated waste rags	Soil pollution
Transmission Switchgear	Faulty transformer oil leaks	Soil and water pollution
	Disposal of waste rags and silica gel	Soil and water pollution
	Weed killer spills	Soil and water pollution Loss of biodiversity
	Disposal of PCB contaminated waste	Soil and water pollution
	Leakage of SF6	Air pollution
Lines	Disposal of creosote treated wood poles	Soil and water pollution
Metering	Disposal of waste meters, cables and CTs	Soil and water pollution
Protection	Disposal of batteries	Soil and water pollution

6.9 Integration of environmental risk assessment and occupational health and safety into ISO 14001 EMS and OHSAS18001

Management systems and standards have become a significant portion of any organisation’s survival and competitive advantage in the twenty-first century. Systems such as Quality Management System ISO 9001 QMS (2008), Environment Management System, ISO14001 EMS, (2004) and occupational health and safety OHSAS 18001, (2007) have become the three main management systems often utilized by organisations. Additionally, some organisations implement financial and asset management systems to manage other aspects of the organisation. However, to realize full benefits from the implementation and subsequent maintenance of these systems, it is only a practical and logical step that the existing management systems/standards are integrated into a single system.

Based on the results from the questionnaires, over 50% of the respondents cited financial benefits (cost saving) as the most important advantage of integrating safety, health, and environmental management functions. They also stated that it is easier to co-ordinate the systems and maintain them if they are integrated.

6.10 Analysis of Results from the new tool

Below in table 6.3 is a summary of results obtained from teams in operations (transmission, generation and distribution) that were given the new tool (which was presented in Chapter 5), to identify environmental risks associated with their processes.

Table 6.3: Environmental risk assessment from transmission, generation and distribution department

Generation Department	
Beginning of operators shift	Disposal of general waste
Hydro generators 1-5 pre starting checks	Disposal of oil contaminated waste rags
Isolation and restoration of 3.3 to 400V feeders	Disposal of waste rags
Monitoring of generator sets	Disposal of waste rags
Dredging operation	Disposal of waste
Maintenance of buildings	Disposal of building rubble
Overhead crane monthly service	Disposal of oil contaminated waste rags
Transmission Department	
Line construction and Bush clearing and maintenance	Storage and disposal of waste material
	Disposal of creosote treated wood poles
Line patrol	Fuel leaks
	Disposal of waste
Substation protection installation (Batteries and charger)	Battery solution spillage
	Disposal of battery cells
HV Yard maintenance	Weed killer spills

	Disposal of broken bulbs
	Faulty transformer oil leaks
HV isolator installation and maintenance	Lubrication spray, densal paste and grease spills
Power transformer installation assembling and maintenance	Disposal of waste rags and silica gel
Meter installation , testing and maintenance	Disposal of waste meters, cables and CTs
Distribution Department	
Planned and reactive maintenance	Disposal of waste electrical components
	Disposal of creosote treated wood poles
	Disposal of scrap transformers
	Disposal of waste transformer oil
New project implementation (connections)	Disposal of waste electrical components
	Disposal of creosote treated wood poles
	Disposal of scrap transformers
	Disposal of waste transformer oil
Packing, stacking and storage of materials	Storage of creosote treated poles and stay bulks
	Transformer oil spillage
	Spillage of hydraulic fluids from crane truck ad HIAB
Storage of fuel	Fuel spills
	Disposal of absorbents
Line inspection	Fuel leaks
Office based activities	Disposal of general waste
	Disposal of cartridges
	Disposal of CFLs
Yard maintenance and management	Detergent spills

6.10.1 Environmental impact

Table 6.4 below indicates that water and electricity resource utilization have a significant impact in the generation department. This can be attributed to the fact that electricity generation is mainly hydro-based hence after generation the water is recycled back into the river. It was also noted that impacts such as soil erosion and disturbance to flora and fauna are non-existent in the generation department.

However, these results are challenged as there has been evidence of soil erosion where water from canals is discharged during maintenance of the generation infrastructure.

The results in Table 6.4 also showed that the transmission and distribution departments have a high potential impact of soil pollution. This can be attributed to leakages from transformer oils and creosote treated poles which are mainly used in transmission and distribution departments. The impact on flora and fauna was also identified for the transmission and distribution departments as most bush clearing is done for the installation and maintenance along line and substation infrastructure.

Table 6.4: Environmental impacts associated with operations departments

Department	Environmental Impacts					
	Water pollution	Air Pollution	Soil Pollution	Flora and Fauna disturbance/ loss	Soil erosion	Water and Electricity resource use
Generation	6	4	7	0	0	5
Transmission	3	2	12	3	1	0
Distribution	7	9	19	6	3	4

6.10.2 Soil pollution

The study also revealed that the leading environmental impact within the company, soil pollution is caused mainly by poor waste disposal, petrochemical spillages and leakages as well as poor storage of materials and waste. It showed that 68% of the soil pollution is caused by poor waste disposal methods (Figure 6.6).

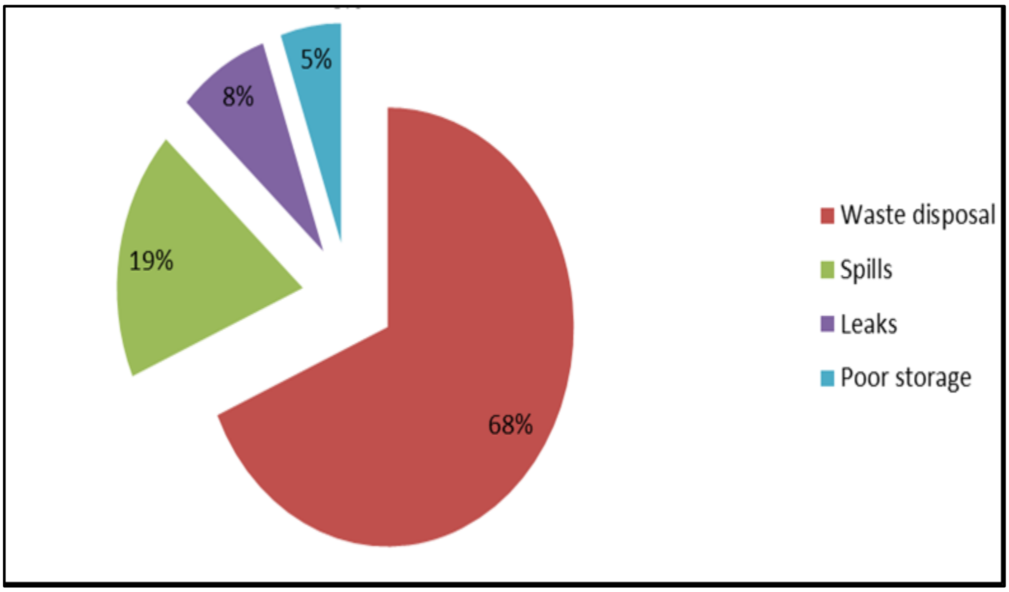


Figure 6.6: Aspects and causes of soil pollution in the operations department

6.11 Occupational health and safety risk assessment

The table 6.5 summarizes data obtained from hazard registers prepared by teams from Generation, distribution and transmission department. The hazards were associated with work activities per department.

Table 6.5: Hazards associated with operations departments

Generation department hazards	
Work Activity	**Hazard**
1. Vehicle use for generation activities	Use of roads with livestock and in bad conditions
2. Dredging	Use of boat
	Use of roads with livestock and in bad conditions
3. Hydro 5 turbine, drive and non-drive bearing inspections	Use of uncertified lifting equipment
4. Overhead crane monthly service	Exposure to live wires
5. Hydro generator 1 to 4 monthly service	Exposure to live wires
6. Main canal pond ad siphon maintenance	Exposure to snakes
7. Maintenance of buildings and work stations	Failure to adhere to building standards
	Use of roads with livestock and in bad conditions
Transmission department hazards	
Work Activity	**Hazard**
1. Line construction	Exposure to live wires

	Poor storage of poles
2. Line patrol	Unsafe driving practices/ use of roads in bad conditions
3. Meter testing	Exposure to live wires
4. Substation protection, battery and charger installation	Exposure to live wires
	Exposure to snakes
5.Battery and charger installation	Explosions/Fire
6.Power transformer installation, assembling and maintenance	Exposure to live wires
7. HV Yard maintenance	Exposure to live wires
Distribution department Hazards	
Work Activity	**Hazard**
1. Planned and reactive maintenance	Exposure to snakes
	Working long hours leading to Fatigue
	Exposure to live circuits/wires
	Use of non-calibrated/ certified instruments
	Working on bad terrain/use of roads in bad conditions
	Working at night leading to Fatigue
	Use of defective equipment
	Uncertified/ untrained employees
	Use of alcohol and drugs in work operations
2. Earthing	Use of non-calibrated/ certified instruments
3. New project implementation (connections)	Exposure to live circuits/wires
	Use of non-calibrated/ certified instruments
	Working on bad terrain
	Use of defective equipment
	Use of inappropriate equipment/machinery
4. Vehicle use during operations and parking	Use of defective equipment
	Driving on bad road conditions
5. Packing, stacking and storage of materials	Poor handling of equipment and material
6. Storage of fuel	Explosion/Fire
	Exposure to snakes
7. Line inspection	Explosion/Fire
	Exposure to live circuits/wires
8. Office based activities	Robbery
	Poor housekeeping
	Lack of warning signage
	Explosion/Fire
9. Yard maintenance and management	Explosion/Fire
	Lack of warning signage
	Use of alcohol and drugs during work operations
	Unsafe driving practices
	Working under adverse weather conditions

	Uncertified electricians/untrained employees
10. Meter reading, inspection, disconnections and debt collection	Exposure to dogs
	Driving on bad road conditions
	Untrained personnel
	Working in adverse weather
	Use of alcohol and drugs during work operations
	Exposure to live circuits/wires
11. Security services and access control	Working at night leading to Fatigue
	Unsafe driving practices
	Exposure to adverse weather

6.12 Hazard consequences

From the results in Table 6.6, the hazard consequences were ranked by site teams from one to 14 according to their set criteria in the methodology.

Table 6.6: Showing Hazard consequence ranking

Category	**Hazards resulting in fatality risks (Categories) #**
Road Hazards	**9**
Use of boats	**1**
Use of uncertified/serviced/ defective/wrong equipment	**7**
Exposure to live wires	**11**
Exposure to snakes	**4**
Exposure to dogs	**1**
Failure to adhere to building standards	**1**
Poor housekeeping/Maintenance	**3**
Explosions/Fire	**5**
Fatigue	**3**
Work being carried out by untrained/uncertified personnel	**3**
Use of alcohol/drugs during operations	**3**
Working on bad terrain	**2**
Poor handling of equipment/machinery	**1**
Robbery/Poor security	**1**
Lack of warning signage	**2**
Working under adverse weather	**3**
Average	**60**

The risks associated with the operations department are more or less the same as those recorded by Federated Employer's Mutual Assurance (FEMA), which includes the electrical environment. FEMA acts as the Workman's Compensation Commissioner for the engineering sector.

According Tulonen (2010) in a study on electrical installations and products in various industries, the respondents gave a list of hazards and their associated risks. These hazards included being in a hurry to complete the tasks, omitting procedures and not reading equipment instructions. Another hazard was working in solitude since in case an accident happens no one will come to help or call for help. In addition, accident risk increases as physically or professionally demanding assignments are done individually. Ill-informed attitudes towards safety were also identified as a risk as they may lead to overestimation of own abilities, callous disregard of own safety and safety of others, instruction violations, and omission of safety procedures.

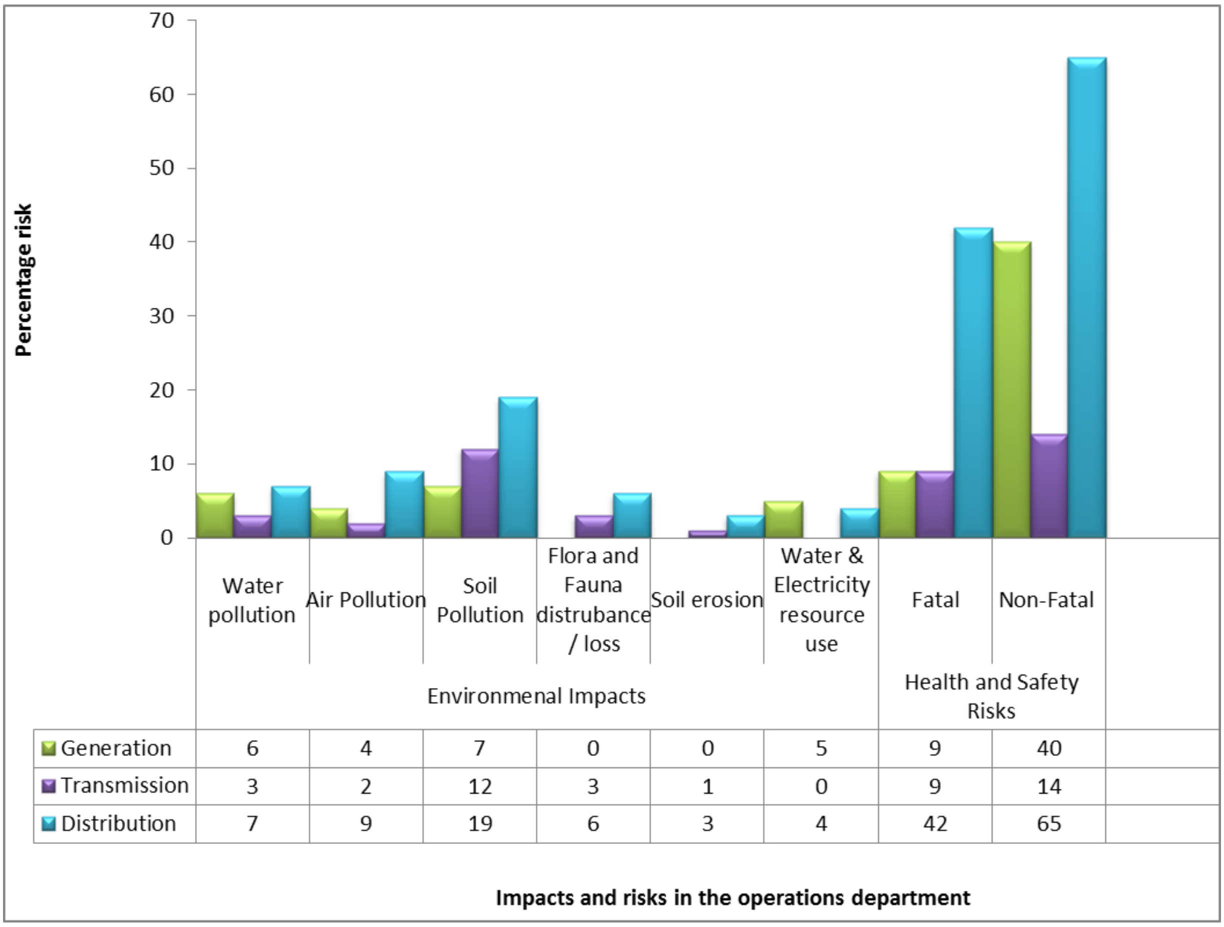
Working conditions were also identified as a risk, specifically adverse weather conditions and environment conditions of the work site, which may change continuously. The other hazards included confined space, poor housekeeping, working at heights, demand working on a ladder or servicing platform. In breakdown-situations working hours may be long and work done alone.

According to the US Occupational Safety and Health Administration most electrical accidents result from unsafe electrical products or installations, unsafe environment or unsafe work practices (Chao and Henshaw 2002).

According to Jeffrey and Fontaine (2012) another hazard is coming in contact with an electrical voltage which can causes current to flow through the body, resulting in electrical shock and burns. Serious injury or even death may occur.

6.13 Environmental impacts and health and safety risks associated with SEC operations

Figure 6.7 shows potential risks within the major operations in the company which might have environmental, occupational health and safety risk implications. It shows that the distribution department has more environmental impacts and health and safety risks. While every workplace is accident prone, there is a special status given to industries, such as electrical distribution, where the consequence of an accident has far reaching implications on the economy, the environment and public safety. Distribution infrastructure is regarded as high-risk and health and safety is of paramount importance to all stakeholders of such concerns (Oke and Omogoroye, 2007).



	Water pollution	Air Pollution	Soil Pollution	Flora and Fauna distrubance / loss	Soil erosion	Water & Electricity resource use	Fatal	Non-Fatal
	Environmenal Impacts						Health and Safety Risks	
Generation	6	4	7	0	0	5	9	40
Transmission	3	2	12	3	1	0	9	14
Distribution	7	9	19	6	3	4	42	65

Figure 6.7: Risk in distribution in different operations of SEC

The results also indicate that soil pollution is the most common environmental impact in the company. Water and electricity resource are mostly used in the transmission and distribution department.

The generation of electrical power poses similar and different risk to other maintenance and engineering activities, although health and safety in the electrical engineering work environment is more regulated, due to better engineering management options Du Toit (2012). This explains why the generation department in this study has fewer risks than transmission and distribution.

6.14 Hazards leading to Occupational health and Safety risks

Figure 6.8 below shows that exposures to live wires present the greatest hazard followed by exposure to road hazards (slippery roads, speeding vehicles, untrained drivers). This was followed by explosions and fires and lastly by exposure to snakes. Fatigue, work being carried out by untrained/uncertified personnel, use of alcohol/drugs during operations had the same percentage 3%.

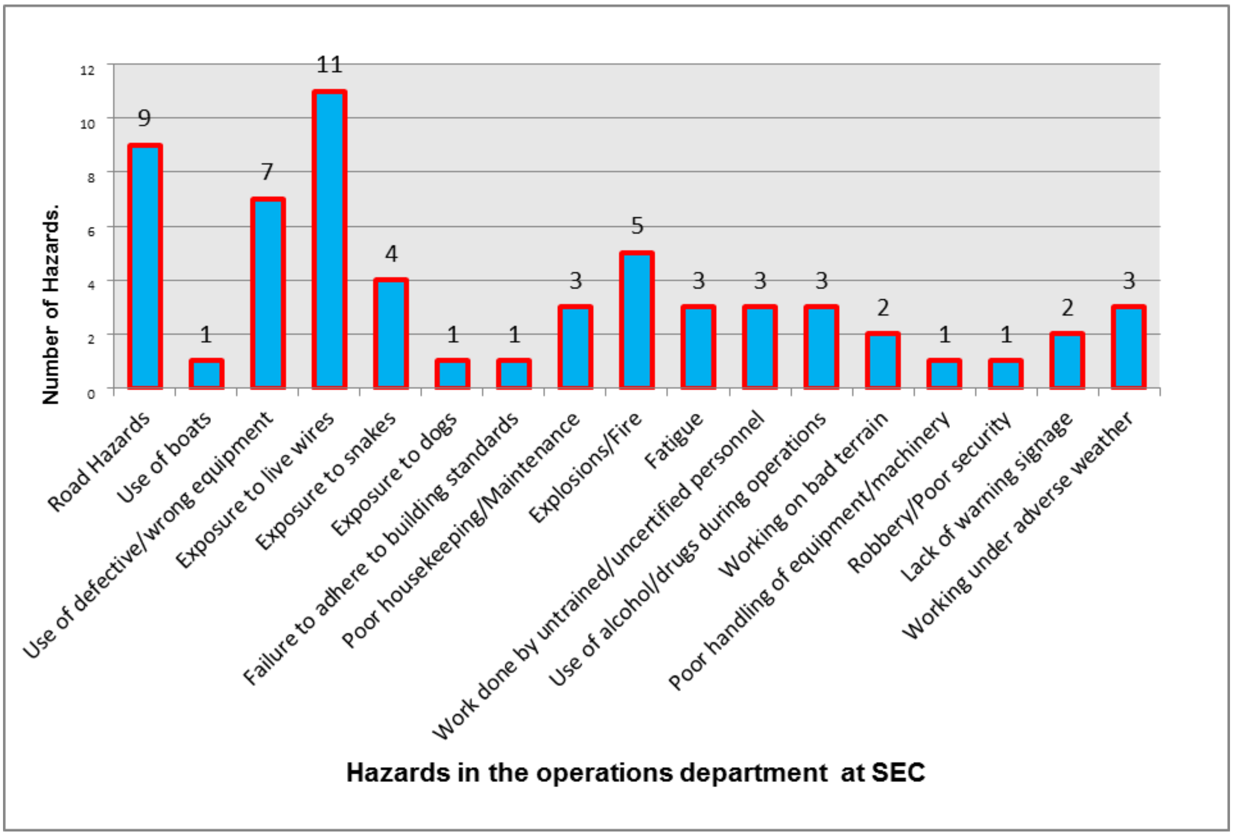


Figure 6.8: Identified hazards likely to cause health and safety risks in percentages

The least rated was the use of boats, exposure to dogs, poor handling of equipment/machinery, robbery/poor security and lack of warning signage. The findings indicate that there is a high risk from exposure to live wires since this is the core business of electricity industry and most workers are concentrated in these conditions. According to Mustonen and Mäkinen (2001) generally electricity risks are caused by the following: accidents happen when work is done live but not in compliance with live work regulations, or because of faulty devices or wiring, inadequate information about the structure of the electrical site, a tool accidentally touching or falling into an energized part, work becoming routine or a disturbance causing attention failure.

Risks in the electrical engineering environment are unique, but also relate to other activities in construction and maintenance. Electrical workers are thus exposed to similar risks as in a construction and maintenance environment, but with the extra hazards associated with electricity.

6.15 Summary of Chapter 6

The results presented above provided the environmental risk profile within SEC. The various occupational health and safety hazards as well as environmental aspects that prevail in this sector were identified. The current mitigation measures and controls have been provided. Generally the significant aspects in the electricity sector are waste disposal, oil leakages (from transformers and generators) and the use of water resources, whilst the significant hazards were observed to be exposure to live wires, working at heights, road hazards (slippery roads, speeding vehicles, untrained drivers), explosions and fires and exposure to snakes.

7 CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter provides the summary of the thesis, research conclusions obtained from this study and a brief research evaluation. Section 7.2 presents a brief summary of the study whilst 7.3 presents conclusions obtained from the study. Section 7.4 focuses on the evaluation of the study, the limitations and future research perspective. Finally section 7.5 presents contributions of this research whilst section 7.6 gives a summary on recommendations for future research.

7.2 Summary of findings

In the electricity industry a number of studies have been done based on Health and safety management and environmental management separately. These studies were not process based rather project based. Hence, there is limited research on environmental risks associated with the electricity generation, distribution and transmission operations. After reviewing, literature it was observed that there was no tool for this industry to identify the environmental risks and effectively manage them in an integrated manner. Therefore the major objectives of the study were:

i) Determination of significant environmental risks associated with the electricity sector in all processes from generation, transmission to distribution of electricity.

ii) Development of an environmental risk assessment tool for operations in the electricity sector

iii) Testing, analysis and validation of the environmental risk assessment tool developed,

To achieve the above objectives literature was reviewed on the evolution of risk assessment and environmental risk assessment concept. An overview on risk assessment and explanation of the tools of risk assessment was made. To identify the environmental risks, two systems OHSAS 18001 (2007), Occupational Health and Safety Standard, and ISO 14001 (2004) Environmental Management System (EMS) systems were used. Lastly, the environmental risks in the electricity sector which is the focus of this study were defined. The environmental risk assessment tool was formulated based on the reviewed literature and operational experiences

To achieve the research objectives a better understanding of business units (generation, transmission distribution and support services) activities and their environmental risks, on-site observations was done. In the onsite observations the potential risks were identified with team members. Team members were selected based on their specific level of expertise and assist during the walkthrough of their facility and operations. Questionnaires were also used to determine the risks associated with various operations and to also test the new tool.

7.3 Conclusions

The research recognized the need for the identification of occupational, health, environmental and safety risks termed environmental risks and provided value to understanding the need for controlling and mitigating risks in the electricity industry. The simpler environmental risk assessment tools developed in this study provided opportunities to minimize and manage risks encountered in the operational division in the electricity sector at the SEC.

The developed tools have been tested and used by competent personnel within various departments in the electricity company. The teams attested that the tools were reliable and user friendly. The aspect of subjectivity was minimized by using consensus when undertaking risk analysis and estimation in the brain storming sessions. Hence the developed tools can be used in any industry, provide an efficient and effective way of risk management.

The salient features of the research are as follows:

- Environmental risk assessment was observed to be critical in the electricity sector in order to ensure improved efficiency and reduced risks during service delivery. This work presented an integrated, continuous, proactive and systematic approach of managing occupational health and safety as well as environmental risks.
- The research developed an innovative tool for assessing risks vis a vis intangible risks; safety and environmental risks associated with the electricity sector from (generation to distribution and finally during transmission).
- The tools were developed within the auspices of ISO 14001 (2004) Environmental management system and OHSAS 18001 (2007) health and safety management system. These two standards were used as they were easily integrated due their strengths in identifying intangible risks; occupational, health, safety and environmental risks. Clause 4.1 of both standards was used to achieve this objective.
- The identification and assessment of the risks as well as their management in this study across the operations division in the company helped reveal the environmental, occupational health and safety risks and their existing controls measures and proposed measures to further minimize risks. This study ensured that the sources of the risks were better understood and the results of the risk assessment process was meaningful and will enhance effective management of risks in the operations department from the risk registers that were developed. This will improve SECs safety and environmental performance.
- The risk assessment methodology used in this research used three parameters namely severity, probability and exposure for occupational health and safety. It differs from the conventional methods of risk assessment in that after identifying the tasks and activities, as well as associated aspects and risks, the following risk analysis criteria were used for the environmental impacts, public concerns, frequency, applicable legislation, as well as existing controls. Public concerns were considered in this research and this emphasized the importance of their views when considering risks.

- The risk analysis and estimation for this research involved the consideration of the risk source. The process employed quantitative and qualitative methods of risk estimation. For the occupational health and safety tool the severity, probability and exposure were used to estimate the pure risks without considerations of any controls or mitigation. Severity, probability and exposure levels were added to determine pure risks. The residual on the other hand was left over once effectiveness of control measures has been taken into consideration meaning that it's the risk that remains.
- This methodology improved greatly as it now brings in the aspect of residual risk which was not considered in the methodology used in chapter 4. This is informative in decision making when it comes to risk management in an organization.
- In order to ensure that there was a comprehensive coverage of all hazards and aspects associated with each process, a team approach was used. Competent personnel provided measures to address risks. The business unit's members knew and understand operational risks better and were therefore better placed to provide resources in terms of competent personnel and in providing measures to address risks.
- The study involved a representative of the employees who carry out the task being assessed, as they knew how the job was actually done, this brought out the experience of abnormal as well as normal conditions and understanding the scope for dangerous shortcuts.
- The research elevated the need for the identification of occupational, health, environmental and safety risks termed environmental risks in this research and provided value to understanding the need for controlling and mitigating risks in the electricity industry. The developed tools aimed to provide an opportunity to minimize risks experienced in the electricity sector.
- The contribution of this research in adding to the body of knowledge in risk assessment is in the identification of environmental risks (occupational health and safety risks as well as environment risks) in the processes in operational departments in the electricity sectors. The development of simpler tools for risk assessment based on ISO14001 (2004) and OHSAS 18001 (2007) clause 4.1 to manage and minimize risks in the electricity sector.

- This research has established a baseline for researchers who will be conducting studies on environmental risk assessment. This study will also help organisations and practitioners as they are trying to ensure continual improvement and meeting the requirements of King 11 act as well as other environmental and occupational health and safety legislations.

7.4 Benefits of the study to SEC

Risk assessment has become a standard phrase in health, safety, and environment management over the last couple of decades. Even though the SEC has heard of it has been thought of as a difficult and complicated process, and as a result, it was often misunderstood. This study came out with a simplified risk methodology that can be understood by all levels of employees in the company. The quantitative analysis has helped the organization understand risks associated with its processes and how best it can ensure that risk occurrences are as low as reasonably practicable and/or have minimal impacts or consequences.

The methodology used involved teams identifying present hazards and aspects associated with the processes in the generation, distribution and transmission of electricity and then evaluating the extent of the risk involved taking into account existing precaution. The involvement of the employees across sections of the hierarchy has allowed for ownership, accountability and active participation towards the management of environmental risks in the company.

Rather than being more reactive, SEC will tend to be proactive towards occupational risks management, a good step towards effectively managing environmental risks associated with its processes. Appropriate mitigation measures are identified and implemented in order to reduce the risks to acceptable levels. Effective communication of identified risks and existing controls as well as periodic review of the process will enable the company and risk assessment methodology to be considerate of changes in technology, processes and products, as a result warranting appropriate and relavante preventative and corrective measures in place. This will ensure that SEC consciously control or eliminate environmental risks.

As a company that subscribes to ISO 14001 and OHSAS 18001 (Environmental and Occupational Health and Safety standards respectively), the methodology that was used will assist SEC in not only complying with the standard requirements but also to continuously retaining certification and thus having a competitive advantage in the electricity sector market.

SEC commits to meeting the needs of its customers in an environmentally and safe manner. By implementing the measures proposed in this study a healthier workplace environment will be created and through enabling active environmental protection throughout the company. Finally the company's image will be enhanced as there will be fewer fines and litigations and loss of lives emanating from the company's operation.

7.5 Recommendations

Recommendations for further research should focus on the recognized need to assess the repeatability and reliability of the environmental risk assessment model and associated methodology. The tool could be used in other utilities and also tried out in other sectors.

7.6 Future research

The immediate development into the tool would be to come up with an enhanced version to ensure that environmental risks, occupational risks and quality risks are identified, assessed and controlled in an organization.

Future research can be undertaken to integrate the three systems occupational health and safety OHSAS18001 which has been upgraded to ISO4500 and ISO9001 (2015) as well as ISO14001 (2015) the revised environmental management system.

The integration of other management system can be studied with a similar approach such as ISO 9001: 2015 Quality Management System and ISO 55000 Asset management.

The ISO 9001 (2015) Quality Management System Standard is focused on risk based thinking and can be used with other ISO systems, hence an integrated risk management approach will be worth investigating. It is anticipated that such systems will enable continuous assessments of the potential risks for the organisation at every level and then aggregating the results at a corporate level to enhance priority setting and improved decision making. As a standard requirement this will ensure that the risk management is embedded in any company's strategy.

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APPENDIX 1: SEC PERMISSION LETTER FOR UNDERTAKING STUDY

Swaziland Electricity Company

Swaziland Electricity Company (SEC)

Head Office, Eluvatsini House
Mhlambanyatsi Road
P O Box 258 Mbabane H100
Tel: +268 2409 4000 Fax: +268 2404 2335

09 June 2014

The University of South Africa
P O Box 392
Unisa
0003

Dear Sir/Madam

RE: PERMISSION TO UNDERTAKE A RESEARCH AT SWAZILAND ELECTRICITY COMPANY

This serves to confirm that Mrs Constance Van Zuydam, student number 36302198 in your institution has been granted permission to use the Company's data to conduct a research on **Environmental Risk Assessment for the Electricity Sector with Respect to Sustainable Development.**

Looking at the background and statement problem of the research topic, we believe that the research would also be of benefit to the organization.

Yours faithfully

MAX B. MKHONTA
GM-CORPORATE SERVICES

APPENDIX 2: CONSENT FORM

CONSENT FORM

TITTLE OF RESEARCH PROJECT

ENVIRONMENTAL RISK ASSESSMENT FOR THE ELECTRICITY SECTOR: A CASE OF SWAZILAND ELECTRICITY COMPANY.

Dear Mr/Mrs/Miss/Ms ________________________________ Date ___________________

NATURE AND PURPOSE OF STUDY

The purpose of this study is to identify and describe the type and extent of the environmental risks attributed to the electricity sector. An environmental risk assessment for the electricity sector will be undertaken where processes from the generation to the distribution of electricity will be assessed. The study makes use of focus group and individual interviews with SEC managers and head of departments and SEC teams who will give their inputs, and detail the risks associated with their processes.

RESEARCH PROCESS

1. The study requires your participation in a focus group interview and an individual interview to determine the environmental risks linked with all critical operations processes within SEC.
2. The focus group will be led by a facilitator who will guide the teams on environmental risk assessment procedures.
3. There is no right or wrong answer.
4. There is no need to prepare anything in advance.
5. Participants will be given an opportunity to express their opinions, they will agree, disagree with the opinion. The teams will be allowed to make a consensus on decisions made.

Your attention is drawn to the fact that photographs will be used to identify some of the risks identified by the groups in specific sites within the company.

CONFIDENTIALITY

The discussions and issues raised by the focus groups are viewed as strictly confidential, and only members of the research team will have access to such information. The published data in journals and dissertations will not contain any information through which focus group members may be identified. To ensure confidentiality you will not be asked to give information which can reveal your identity, hence your anonymity will be ensured.

WITHDRAWAL CLAUSE

I understand that I can withdraw from the focus group at any time. I participate voluntarily until such a time as I request otherwise.

POTENTIAL BENEFITS OF THE STUDY

This study will ensure that environmental risks (safety and environmental) associated with processes in the electricity sector are identified. A further benefit from this study is that a simple environmental risk assessment tool to cater for safety and environmental risks specifically for the electricity industry processes will be developed. This tool will help the organisation to easily develop proactive and integrated strategies for managing environmental risks holistically. The knowledge of the critical areas that would have an impact on organisation's safety and environmental profiles will improve performance as these issues will receive more attention once they have been evaluated and rated.

INFORMATION

If I have any questions relating to the study, I may contact Constance van Zuydam at 00268 76035890 or Professor Moja at +2712 841 1485

CONSENT

I, the undersigned,……………………………….. (full name) have read the above information relating to the project and have also heard a verbal version, and declare that I understand it. I have been offered the opportunity to discuss relevant aspects of the project with the project leaders and hereby declare that I agree voluntarily to participate in the project.

I indemnify UNISA and any employee or student of UNISA against my liability that I may incur during the course of the project.

I further undertake to make no claims against UNISA in respect of any damage to my person or reputation that may be incurred as a result of the project trial or through the fault of other participants, unless resulting from negligence on the part of UNISA, its employees or students.

Signature of participant ……………………………………………………………

Signed at………………………………………..on………………………………

WITNESS

1…………………………………………………………………………………….

2……………………………………………………………………………………

9 APPENDIX 3: ETHICS CLEARANCE FROM UNISA

UNISA university of south africa

CAES RESEARCH ETHICS REVIEW COMMITTEE

Date: 10/11/2014

Ref #: **2014/CAES/144**
Name of applicant: **Ms CS Van Zuydam**
Student #: **36302198**

Dear Ms Van Zuydam,

Decision: Ethics Approval

Proposal: Environmental risk assessment for the electricity sector: A case of Swaziland Electricity Company

Supervisor: Prof SJ Moja

Qualification: Postgraduate degree

Thank you for the application for research ethics clearance by the CAES Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the project.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the CAES Research Ethics Review Committee on 06 November 2014.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the CAES Research Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.*
3) *The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and*

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Open Rubric

scientific standards relevant to the specific field of study.

Note:

The reference number [top right corner of this communiqué] should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the CAES RERC.

Kind regards,

Signature
CAES RERC Chair: Prof EL Kempen

Signature
CAES Executive Dean: Prof MJ Linington

PLEASE NOTE PROVISIONS.

10 APPENDIX 4: QUESTIONNAIRE

QUESTIONNAIRE

SECTION 1: GENERAL INFORMATION

Instruction: Please mark ONLY ONE square with an x

A1 Please indicate your age bracket

Age	
20-30	*1*
31-40	*2*
41-50	*3*
Older than 50	*4*

Office use
1
2
3
4

A2 Indicate your gender

Gender	
Female	***1***
Male	*2*

Office use
5
6

A3 How many years have you served as an SEC employee?

Years	
0-5	*1*
5-10	*2*
11-15	*3*

Office use
7
8
9

A4 What is your highest level of qualification?

Qualification	
Form 5 or Matric	*1*
Diploma	*2*
Degree	*3*
Post Graduate	*4*

Office use
11
12
13
14

A5 Have you been trained on the following SHERQ issues?

Qualification	
Environmental assessment	*1*
SAMTRAC	*2*
NOSA/Safety	*3*
Incident Investigation	*4*

Office use
15
16
17
18

A6 Please indicate your division

Division	
Customer services	*1*
Operations	*2*
Corporate	*3*
Support services	*4*
Finance	*5*
Research and development	*6*

Office use
19
20
21
22
23
24

SECTION 2 RISK MANAGEMENT

A7 Which risk management functions of the organisation have you been engaged in?

Risks			**Office use**
Financial risks	*1*		*25*
Safety risks	*2*		*26*
Environmental risks	*3*		*27*
Security risks	*4*		*28*
Quality risks	*5*		*29*

A8 Please indicate specific processes in your department

A9 What are risks associated with the processes you involved in?

Business Process	*Risk*	*Proposed mitigation*

Office use
30

A10 Which tools have you been using to identify your risks

Risk Assessment Tool	*Outcome*

Office use
31

A11 Which of the following risk assessment tools does your organisation apply as secondary tools to measure its Health and Safety risks?

Secondary Risk Assessment Tool	*Outcome*
Checklists	*1*
Hazard Indices	*2*
Monte-Carlo Simulation	*3*
Common Mode Failure Analysis	*4*
Category Rating	*5*

Office use
32
33
34
35
36

A12 Was the tool easy to use what are your recommendations?

A13 Do you think risk assessment of safety health and environment must be integrated and why?

11 APPENDIX 5: RISK ASSESSMENT PROCEDURE

Evaluation of Risk

The purpose of this procedure is to ensure that all environmental aspects of the company's operations and activities are identified and that the significance of their environmental impacts are assessed to permit improvement objectives and the implementation of necessary control measures. These procedures addressed routine and non-routine activities, including contractors and visitors having access to the workplace.

Scope

This procedure covers all environmental aspects and impacts undertaken at the following business units which creates controls or has reasonable influence over. These included those; relating to current, past and proposed future activities and occurring under normal, abnormal or reasonably foreseeable emergency conditions

The risk evaluation process was carried out by a selected team of competent personnel depending on the issues being addressed. The risk evaluation methodology was assessed using the scoring tables shown below and the risk assessment process by Newbury, (2006).

Criteria = Frequency

SCORE	DESCRIPTION
1	Negligible usage, infrequent operation
2	Low usage / Normal Operation
3	Moderate usage / frequent Operation
4	Very high usage / Emergency Conditions

Criteria = Legislation

SCORE	DESCRIPTION
1	No relevant legislation
2	Complies with legislation
3	Potential Breach / lack of awareness
4	Breaching legislation

Criteria = Environmental effect

SCORE	DESCRIPTION
1	Insignificant environmental effect
2	Minor environmental effect
3	Moderate / Potential major environmental effect
4	Major environmental effect

Criteria = Concern

SCORE	DESCRIPTION
1	Insignificant / No concern
2	Limited / Minor Concern
3	Moderate / Potential major concern
4	Major Company concern

Criteria = Controls

SCORE	DESCRIPTION
1	Full control / no need for control
2	Moderate Control
3	Limited/Minor Control
4	No Controls

Criteria = Factor

TOTAL SCORE	**LEVEL OF SIGNIFICANCE**
1 -9	Low level of Concern
10-15	Medium Level of Concern
16-20	High Level of Concern

The intention is to reduce impacts to "as low as reasonably practicable" (ALARP)

Having assigned a priority score for each environmental aspect and impact, Table 4.1 was used to suggest timeframes for managing different priority environmental aspects and impacts. The actual timeframes shall be agreed with process owners.

Table 4.1 Time frames of managing environmental aspects and impacts

	Risk	Action	Timeframe
(red)	High	Short Term	Within 3 months
(yellow)	Medium	Medium Term	Within 6 months
(green)	Low	Long Term	1 year +

FORM 1: Aspects identification form

INPUTS (Intended and Unintended)	**ACTIVITY/PRODUCT/SERVICE** (To be filled in first)	**OUTPUTS** (Intended and Unintended)	**ASPECTS**

FORM 2: Aspect / impact significance form

Aspects/Impacts Significance Assessment						Record Number:						
						Date:						
Service/Activity/Product:												
Aspect/Impact:						Impact/Risk:						
						Ref:						
Condition	Rating Comment:											
												Total Impact rating/Risk Criticality
	Frequency	Score	Legislation	Score	Environ effect	Score	Concern	Score	Controls	Score		
Normal/Routine												
Abnormal/Non Routine/ Start-up/Shut-down												
Emergency												

FORM 3: ASPECT REGISTER

ACTIVITY/PRODUCT /SERVICE	ASPECT	IMPACT	MEASURES	LEGAL and OTHER REQS	CATEGORY (Insignificant Moderate Significant)	MITIGATORY ACTIONS (Reference supporting documents where necessary)	RESPO.	REF.

FORM 4: OBJECTIVES AND TARGETS

No.	OBJECTIVES AND TARGETS	TECHNOLOGICAL OPTIONS (Reference supporting documents where necessary)	FINANCIAL,OPERATIONAL and BUSINESS REQUIREMENTS (Reference supporting documents where necessary)	VIEWS OF INTERESTED PARTIES (Reference supporting documents where necessary)

FORM 5: Objectives and targets consideration form

ASPECT and SIGNIFICANCE (Rate significance)	**OBJECTIVE**	**TARGET(S)**	**ENVIRONMENTAL COMMITMENT POLICY**	**LEGAL and OTHER REQUIREMENTS** (Reference supporting documents where necessary)	**RESPO.** (Person)

FORM 6: Hazard/ risk assessment

Department	
Compiled by	
Date	
Scope	**Hazard /risk assessment**

Task		Frequency	Severity	Rating	Mitigating risk	Frequency	Business impact	Incident impact	Legal impact	Environmental impact	Mitigatory controls and actions	Legal reference