Journal of
Geography & Natural Disasters

van Zuydam et al., J Geogr Nat Disast 2016, S6
DOI: 10.4172/2167-0587.S6-006

Research Article

Open Access

Hazard and Risk Assessment in Electricity Sector: A Case of Swaziland Electricity Company

Moja SJ[1,2], Van Zuydam CS[2,3]* and Mphephu F[2,4]

[1]Sustainable Resources and Environment Competency, Council for Geoscience, 280 Pretoria Street, Silverton, Pretoria, 0001, South Africa
[2]Department of Environmental Sciences, Florida Science Campus, University of South Africa, Corner of Christian de Wet and Pioneer, Florida, 1710, South Africa
[3]Swaziland Electricity Company, Luvatsi house, Mbabane, Swaziland
[4]Fred Consulting Engineers, Halfwayhouse, 1685, Johannesburg, South Africa

Abstract

The provision of safe, reliable and affordable power supply is one of the most important cornerstones for economic development. The risks range from minor to major risks such serious body injuries to fatalities; some of which have a cascading effect to dependents of the affected. Hence, electricity operations as well as its utilization are considered to be high risk.

The focus of this paper is to identify the hazards and risks associated with the various processes involved in each step and suggest possible measures to control the identified risks. The Swaziland Electricity Company (SEC) was used as a case study wherein the company's generation, transmission and distribution capabilities were audited. The top three significant hazards identified included; exposure to live wires, road hazards and the use of uncertified/serviced/defective/wrong equipment and/or machinery. The distribution department was observed to have the most hazards and fatalities when compared to the other departments. This work determined hazards associated with the electricity sector and developed a simplified tool for hazard identification which can be used by other sectors. The data obtained in the hazard registers will act as baseline information for other electricity utilities wishing to implement health and safety systems. The study provides information on currently used control measures and proposes additional measures that could help improve the safety performance of Swaziland Electricity Company and facilities of similar kind.

Keywords: Hazard; Hazard identification; Risk assessment; OHSAS18001:2007; Risk; Risk analysis; Risk management; Safety; Electrical hazards; Control measures

Introduction

The electricity industry provides an essential commodity to modern life, both at industrial and domestic levels to the average middle-class person. Electricity plays a major role in providing basic services and meeting basic human needs, such as jobs, food, running water, sanitation, and education and health services. Addressing these issues, inevitably involves an increase in the level of electricity service. Unfortunately though used extensively, electricity use comes with overabundance of associated risk and hazards, most of which are oblivious to end user [1]. Electrical hazards cause more than 300 electrocutions and 4000 injuries in workplaces each year, disrupting lives, and impacting on productivity in companies. In an African context, the Federated Employers Mutual Assurance Company limited [2] indicated that electricity related incidents accounted for 0.58% of incidents and the related fatality rate was 4.8% in 2011. According to Occupational Health and Safety Administration (OSHA) an average 12,976 lost workday injuries and 86 fatalities related to employees working in power generation, transmission and distribution occur annually. Hence Therefore, OSHA recognizes electricity as a long term serious workplace and public hazard exposing employees and the public to dangers such as electric shock, burns, fires, explosions and fatalities. Hence, it is very important to identify hazards, manage the identified risks to improve operational performance risks and satisfy customer needs and those of interested parties. It is also anticipated that such a proactive approach to risk management will result in massive cost savings, and a reduction in compensation claims as well as noncompliance with health and safety legislation.

Best performing industries do not only ensure a good quality product or service but also ensure that their working environment and surroundings are safe which results in satisfied employees customers and interested parties. Hence risk assessments are quite necessary and the proposed actions need to be put in place to minimize risks to tolerable levels on a continuous basis. Nordgård [3] states that there is an increased awareness to incorporate risk analyses into the companies' decision making and such risks include economic, safety and environmental impacts. Additionally solutions must be sought for risks and that all risk aspects are must be sufficiently taken care of. Therefore this motivates for the use of various risk assessment methods to ensure that all risks are identified and controlled to acceptable levels. This paper therefore present the risk assessment methodology used in the electricity sector in Swaziland. The basic step of the framework generally follows risk management principles based on Australia/New Zealand Standard [4].

This study's main objective was to identify the hazards associated with each step involved in the generation, transmission and distribution of electricity at SEC and to generate controls to ensure that risks are eliminated or reduced to tolerable level. The hazard identification and risk assessment tool were developed from clause 4.3.1 of OSHAS 18001 to improve safety at Swaziland Electricity Company.

Section 2 of the paper presents the definition of hazard identification and risk assessment with reference to some concepts from literature.

***Corresponding author:** Constance Sthembile van Zuydam, Swazilan Electricity Company, Mbabane, Mbabane, South Africa, Tel: +(268)76035890; E-mail: constance.vanzuydam@gmail.com

Received December 13, 2016; **Accepted** December 26, 2016; **Published** December 30, 2016

Citation: Moja SJ, Van Zuydam CS, Mphephu (2016) Hazard and Risk Assessment in Electricity Sector: A Case of Swaziland Electricity Company. J Geogr Nat Disast S6: 006. doi: 10.4172/2167-0587.S6-006

The proposed simplified tool is then presented in section 3. Section 4 concludes the findings of the study.

Background

Hazard identification and risk assessment: The hazards are defined as potential or harm or all aspects of technology and activity that produces risks [5]. Whilst risk assessment is about deciding who might be harmed and then judging how likely it is something goes wrong, and how serious the consequences could be and how to reduce it to as low a level as possible [6]. The Health and Safety Executive [7], Kaplan and Garrick [8]; Gillett defines risk assessment as a process that determines the degree of risks that employees face from exposure to health and safety hazard arising from a given activity, facility or system at work and to establish controls requiring prioritization.

In this paper risk assessment refers to the process that identifies the hazards associated with particular activities/tasks on electricity sites, evaluates the effects and estimate hazard or aspects of exposure to these hazards. These are then prioritized, controlled and reviewed continuously. The outcome of this process is to dictate what applicable and suitable monitoring and measurement, training operational control, objectives and targets as well as related safety programmes must be put in place by the organization [9].

Methods for hazard identification and risk identification: Carter and Smith argue that risk identification is the most important stage of the risk assessment process. Various categories of methods have been used for hazard identification and risk assessment. These are simplified risk analysis (coarse analysis), standard risk analysis (brain storming sessions, HAZOP, risk matrices and Job safety analyses) and model based risk analysis (fault tree analysis, Bayesian networks, electrical system simulation [10]. It has been argued that empirical studies of risk management practice show that checklists and brainstorming are the most usable techniques for identifying hazard as per Lyons & Skitmore. This study utilized the standard risk analysis which involved brain storming sessions. The other methods were not chosen since they are more formal, laborious and sophisticated.

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.

General framework of risk assessment: Risk assessment 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. Five stages of risk assessment have been identified, which are establishing the context, identifying the risk, estimating the risk, evaluating the risk and controlling/responding to the risk. This has been adopted from a framework by Australia New Zealand risk standard 2004 as shown in Figure 1.

A simplified version has been developed from this framework for this study has shown below in Figure 2.

Methodology for Hazard Identification and Risk Assessment

The steps in the following sections highlight the tool that was used for hazard identification and risk assessment at Swaziland Electricity Company, the case for the study.

Planning

Sampling and data collection: In this research study, sampling involved the various business units of the electricity company; Operations, Customer Services, Finance, Support services and Corporate services. The sampled business units were generally those representing operations namely power generation, transmission, and distribution and the study explored the safety hazards associated these units. The study employed qualitative and quantitative research techniques to arrive at the purported objectives. The research used a field survey where questionnaires and interviews were used for data

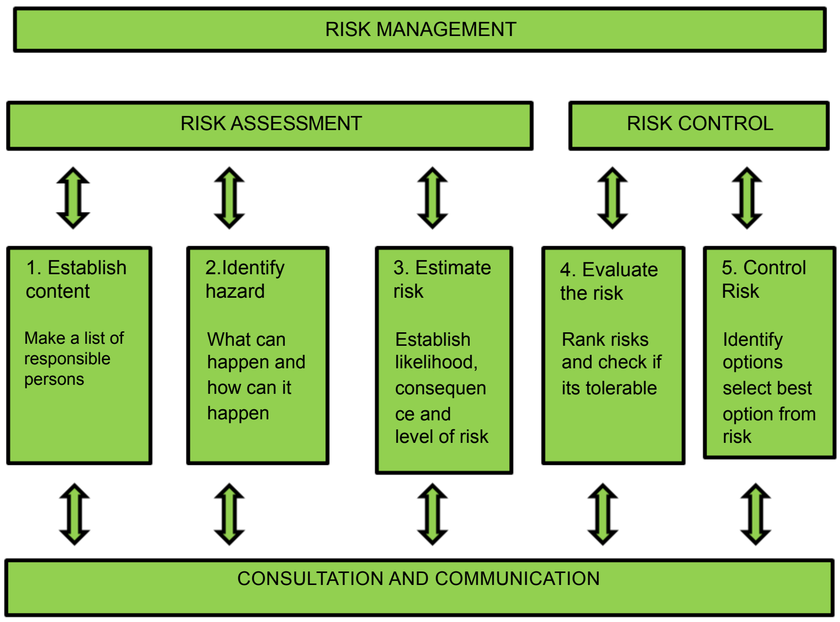

Figure 1: Shows hazard identification adopted from Australia New Zealand risk standard (2004).

collection as well as brainstorming sessions with teams of experts from the various electricity operations. To obtain a better understanding of business unit's activities and their environmental risks, on-site observations were done and brain storming sessions were conducted by the researcher. The business unit teams consisted of experts for instance (electrical technician or engineer, mechanical engineer, equipment operators, the safety officer, station manager and the researcher).

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.

Hazard identification

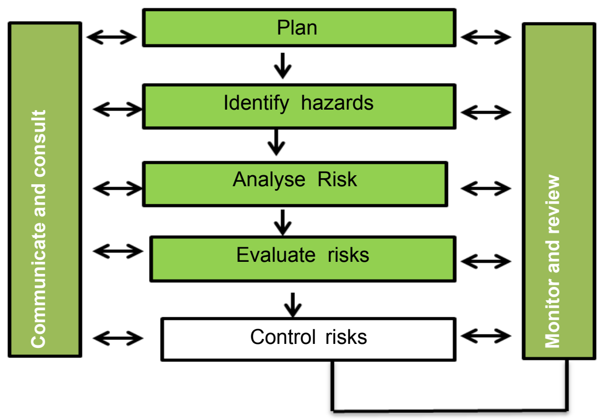

Figure 2: Hazard identification process and risk assessment process which has been used in this study.

Data collection was based on the following, experienced employees who were well versed of their daily activities and associated risks and control and a competent team to do the hazard identification. According to clause 4.3.1 there are various methods of hazard identification including, job safety analysis (JSA), Hazard and operability Analysis (HAZOP) and what if method. The business unit's teams from (generation, transmission and distribution) assembled and conducted the Hazard identification and Risk Assessment (HIRA) following the process using the chart in Figure 3.

A team of experts from the sampled business units engaged in a brainstorming session. For the hazard identification step, the business units listed all activities and processes in their departments. This included all activities which are carried out in routine, emergency and non-routine basis. They identified all processes and related inputs and outputs and determined the associated hazards. The business units had to determine the hazards, who could be harmed and how. They also had to identify legal requirements related to activities carried out and related controls. This stage was meant to determine potential risks associated with activities performed by personnel as well as other people exposed such as visitors and contractors.

Risk analysis/evaluation

The hazard identification stage was followed by risk analysis where the hazards and associated risks were evaluated. It determines the significance of risk and judges whether a risk is acceptable or not. In this stage the business units had to determine how many people were exposed to the risk and for how long. This required that the business units determine the probability and severity of the harm by having an appreciation of a day's work flow activities in the operations department. They had to agree and allocate some scores based on the following factors; severity, probability, exposure and hierarchy of controls. Consensus was reached where they had varying scores and mitigation measures were proposed for that noted variation. The probability, severity and exposure ratings were summed up to

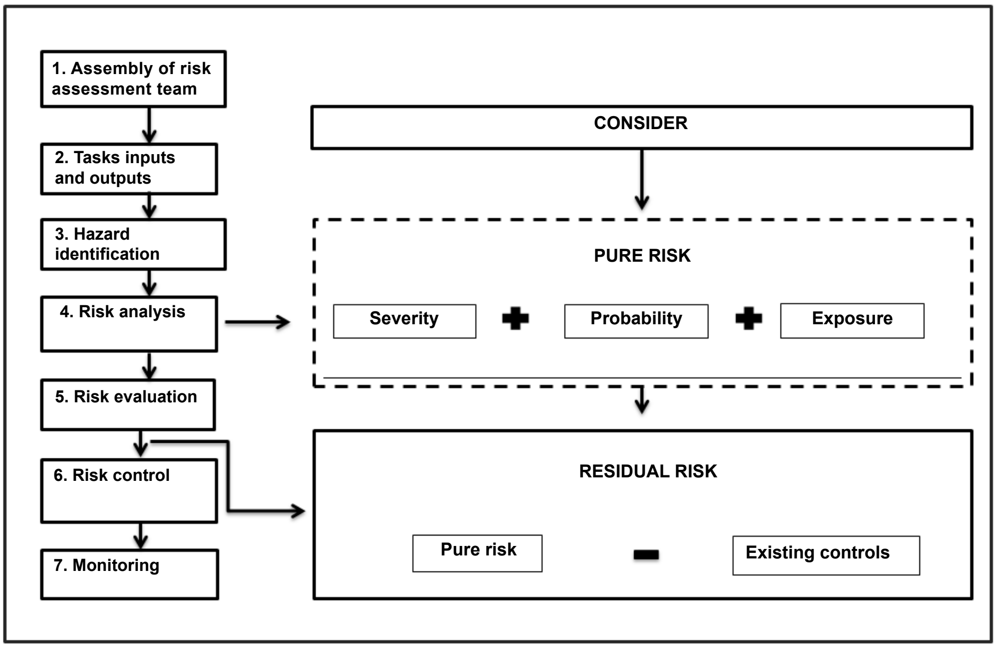

Figure 3: Hazard identification and risk assessment process.

determine the pure risk. This is the risk without taking into account the existing controls. The tables shown in the next sections and criteria were used to analyses the risks.

Hazard Evaluation criteria for safety and significance determination

Risk assessment and significance evaluation were identified and rated as stipulated in the Tables 1-4 in the next section based on severity, probability, exposure and controls.

i) **Severity;** What will the severity or consequence of the hazard be?

ii) **Probability:** How likely can the risk consequence occur?

iii) **Exposure:** The consideration is made concerning how many people are exposed to each hazard and for how long.

iv) **Controls:** How much of the personnel are likely to be exposed?

Once severity, probability and exposure were determined, the business unit 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

v) **Existing controls:** What current controls or mitigation measures are in place?

vi) **Occupational health and safety risk classification:** The above process relied on the team's collective judgment of assessing the risks and determining its significance. Risk identification terms such as high, medium and low were used to classify the risk. Table 5 below was used to determine the action required to address the risk once it has been classified. The greater the risk implies that immediate action needs to be taken to reduce the risk to a tolerable limit.

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

Table 1: Severity rating (adopted from NOSA 2012 and modified).

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

Table 2: Probability rating (adopted from NOSA 2012 and modified).

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

Table 3: Exposure rating (adopted from NOSA 2012 and modified).

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.

Table 4: Hierarchy of control rating (adopted from NOSA 2012 and modified).

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

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

Table 5: Risk classification and action source [14].

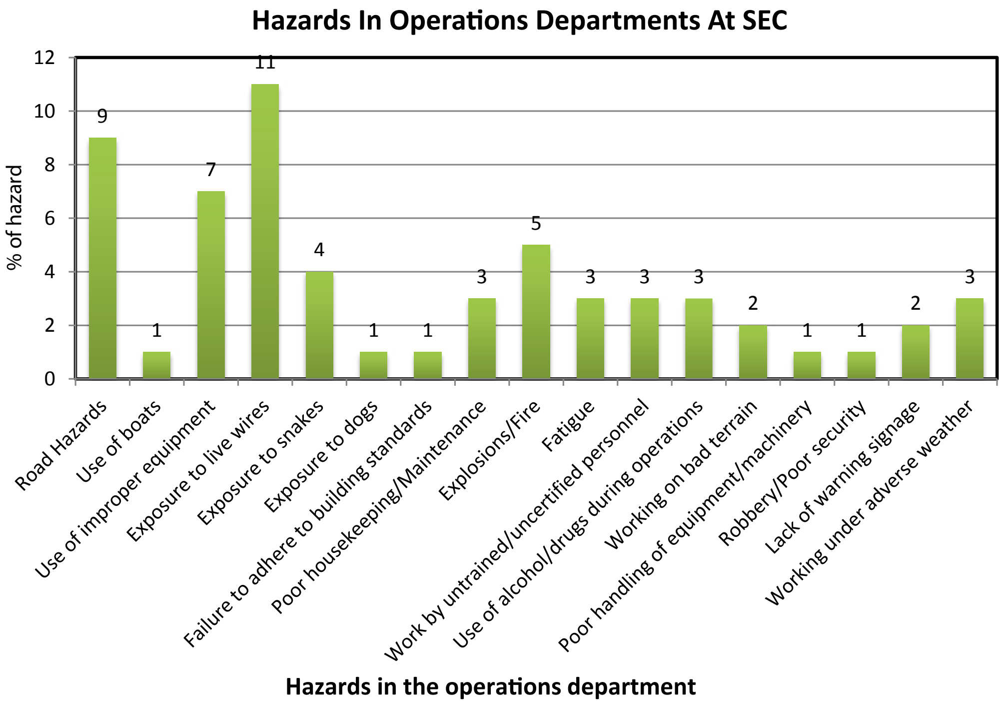

Figure 4: Summary of hazards in the operations department at Swaziland Electricity Company.

Departments	Health and Safety Risks	
	Fatal	Non-fatal
Generation	9	41
Transmission	9	14
Distribution	42	65
TOTAL	60	120

Table 6: Health and safety risks leading to fatality in the operations department.

Result and Discussion

The hazard identification and risk assessment was conducted for the operations department (generation, distribution and transmission) at Swaziland Electricity Company. The results for the generation's department are presented in the risk register below:

Hazards identified per department

The hazards identified per department at SEC are presented in Figure 4 which indicates that the top five hazards in the operations departments at SEC are exposure to live wires, road hazards, use of improper equipment (defective and uncalibrated), explosions and fires and snake bites. These need proper controls and monitoring. Working under adverse weather, poor housekeeping, fatigue, and use of alcohol work by unskilled, uncertified personnel is also prominent hazards and need to be monitored and controlled (Table S1 shown as supplementary file).

Health and safety risks that can result in fatalities

Health and Safety Risks that could result in fatalities were identified and are presented in Table 6. Below and indicate that 54% of the health and safety risks that lead to fatalities are forms the distribution department. The transmission department accounted for 12% of risks that leads to fatalities. This is in line with findings by Kinnunen [11] who observed that most fatalities in Norway were associated with over headlines in electricity transmission and distribution companies.

Conclusion

The main objective of this research paper was to identify and assess risks associated with the electricity sector mainly in the operations department (generation, distribution and transmission of electricity) at the Swaziland Electricity Company. The hazard identification and risk assessment tool used was based on clause 4.3.1 of OHSAS 18001 [12]. Due to the fact that the other risk identification and analysis method are laborious and complicated, the simplified risk analysis method was used in this study.

The information gathered from the identification and management of hazards will form an important part of a safety programme for management and control of risks within the company. The study will improve occupational health and safety at Swaziland Electricity Company because the produced risk registers of existing controls were identified and additional controls for the risks have been proposed. This study enabled the company to prioritize the risk so that focus can be made to those requiring immediate action [13-15].

The information and tools used for the hazard identification and risk assessment can be used by other utilities. The registers developed in this study can be used as baseline for electricity utility safety programs.

It is however recommended that such as study be undertaken in various utilities and compared to determine if the risks and their magnitude are similar.

References

1. Occupational Safety and Health Administration - OSHA (2011) Electric Power Generation, Transmission, and Distribution; Electrical Protective Equipment. Washington DC: US Department of Labor; 1994 standard number 1910.269.

2. FEMA (2011) Federated Employers Mutual Assurance Company limited. Statistics and causes of incidents in the engineering environment.
3. Nordgård DE (2010) Risk analysis for decision support in electricity distribution system asset management: methods and frameworks for analysing intangible risks. PhD thesis, NTNU, Trondheim.
4. Australian/New Zealand Standard) (AS/NZS) (2004) Risk Management. New Zealand. Standards.
5. Manuela FA (2010) Acceptable risk time for SHE professionals to adopt the concept. Professional Safety 30-38.
6. Mondarres M, Kaminky M, Krivtsov V (1999) Reliability Engineering and Risk Analysis Quality and Reliability. A series edited by Schelling E.G, Marcen Inc. New York.
7. Health and Safety Executive (2004) Improving health and safety in the construction industry. London: The stationary office.
8. Kaplan S, Garrick J (1981) On the Qualitative Definition of Risk. Journal of Risk analysis 1: 11-27.
9. NOSA (2002) Introduction to SAMTRAC Course. First Edition. NOSA (PTY) Ltd.
10. Aven T (2008) Reliability and Risk analysis. London. Elsevier.
11. Kuninnunen M (2013) Electrical accidents hazards in Nordic countries. Master thesis. Tempere University of technology, Finland.
12. OHSAS18001 (2007) Occupational Health and Safety Assessment Series. London.
13. Valsamakis C, Vivian RW, Du Toit GS (2004) Risk management. Managing Enterprise Risks (3rdedn) Sandton: Heinemann
14. Newbury (2006) Tools integrated risk assessment and audit in support for an integrated safety health and environmental management system. NOSHCON. Suncity
15. Rahmani A, Khadem M, Madreseh E, Aghaei H, Raei M, et al. (2013) Descriptive study of occupational accidents and their causes among electricity distribution company workers at an eight-year period in Iran. Safety and Health at Work 4: 160-165.

This article was originally published in a special issue, **Environment: Globalization and Urbanization** handled by Editor. Dr. Raymond J. Dezzani, University of Idaho