RISK MANAGEMENT IN ELECTRICAL DISTRIBUTION SYSTEM IN SRI LANKAN HOTEL INDUSTRY

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ABSTRACT

An uninterrupted service throughout the facility is a must for building services in the hotel industry because a large part of guest satisfaction with the hotel depends on building services. However, building services face many different types of failures due to various risk factors. Therefore, a risk management framework is an essential part of the building services of a hotel. In case of hotel buildings, the literature suggests electrical power distribution system (EPDS) to be the key building service which governs all other building services and failure in the EPDS can happen due to maintenance risks, operational risks, assets specific risks and human errors. This research was commenced through a study of three leading five star hotels in Sri Lanka. Based on the research findings, a risk management framework was developed to address risks in EPDS of a hotel facility. The risk management framework was developed based on these findings reveals effective practices that could be used to reduce failure in EPDS. The research also pointed that maintenance risk, unplanned operational risk, asset-specific risk and human errors as the main internal risk factors that lead to failures in EPDS. On the other hand, weather conditions was identified as the uncontrollable external risk factors in the hotel industry, a preventive and a predictive maintenance schedule, planned operations, training and development, and proper asset selection criteria were identified as the main risk management strategies used in the hotel industry. The paper proposed a risk management framework to overcome the identified risks in EPDS in hotel industry which consist of failure mode effect analysis, power monitoring panel and a risk mitigation plan to maintain continuous operations in the EPDS. The findings and recommendations of the study will be useful to those responsible for EPDS operations in the hotel industry for the purpose of reducing services failures.

Key words: *Electrical Power Distribution, Risks, Service Failure, Risk management Framework.*

1. INTRODUCTION

Hospitality is indubitably a people-centred business, which provides both security and physical and psychological comfort for an appropriate fee. In hotels, both the owners and staff therefore are concerned with the condition and sustainability of constructed facilities as well as intangible aspects and ambience of the hotel premises. These form a major part of the product sold to guests, (Okoroh *et al.*, 2002). Nowadays, hotels therefore offer a range of facilities for the purpose of providing high levels of comfort and services for the guests. These include building services, catering facilities, function rooms, meeting and conference facilities etc. (Mohammad, 2009). However, according to Phau and Baird (2008), guests at hotels are more concerned about satisfaction derived through building services.

Studies have identified key building services that directly impact the service quality provided in a hotel as air-conditioning, electricity, cold water distribution system, hot water and steam distribution system, fire detection and prevention system, lighting, internal transportation system, security system, and telecommunication system (Heimonen *et al.*, 2003; Malatras *et al.*, 2008; Phau and Baird, 2008).

However, most of the key building services identified are generally regarded as major electricity consumers (Yu and Chan, 2005). For example air-conditioning, ventilation and lighting systems cannot operate without electricity (Yu and Chan, 2005). Kamaruzzaman and Edwards (2005) highlighted that, total operations of the building services are based on the electrical power distribution of the hotel. It mainly consumes the high voltage power to run the operations. Also as Yu and Chan (2010) highlighted, high electricity demand of a hotel is very critical to maintain, because the guests who are in the hotel use

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different types of services which run based on the electrical system within 24 hours. Therefore, electrical power distribution system is identified as the key and essential system to the proper functioning of the hotel building.

Every process is susceptible to fail and for the electrical distribution system there's no difference. The electrical power distribution system can failed in different location from the main sub-station to minor circuit breaker. However, these electrical system failures may lead to the overall system performance degradation and also it can cause to congest the total operation of the hotel building as electricity is the main power source of most other building services (Chan *et al.*, 2001). As a result the good will, brand loyalty and market share of the hotel can decline due to guest dissatisfaction (Oh and Parks, 1997). Therefore, it is necessary to have a system to identify the risks which can cause failures in the EPDS beforehand. Accordingly, this study was the aimed to propose a risk management framework for the EPDS in hotel buildings.

2. THE ROLE OF ELECTRICAL POWER DISTRIBUTION SYSTEM IN A HOTEL

Energy consumed by hotels includes electricity, gas and diesel, but the energy consumption is dominated by electricity in terms of both rate of consumption and the cost (Yu and Chan, 2005). Therefore, electricity takes a major role for sustaining the hotel in the current situation. According to Yu and Chan (2005) electricity is used mainly for air-conditioning, ventilation and lighting in a hotel building.

2.1. COMPONENTS OF AN ELECTRICAL POWER DISTRIBUTION SYSTEM

The EPDS comprised of six main components with different functional requirements (see Figure 1).

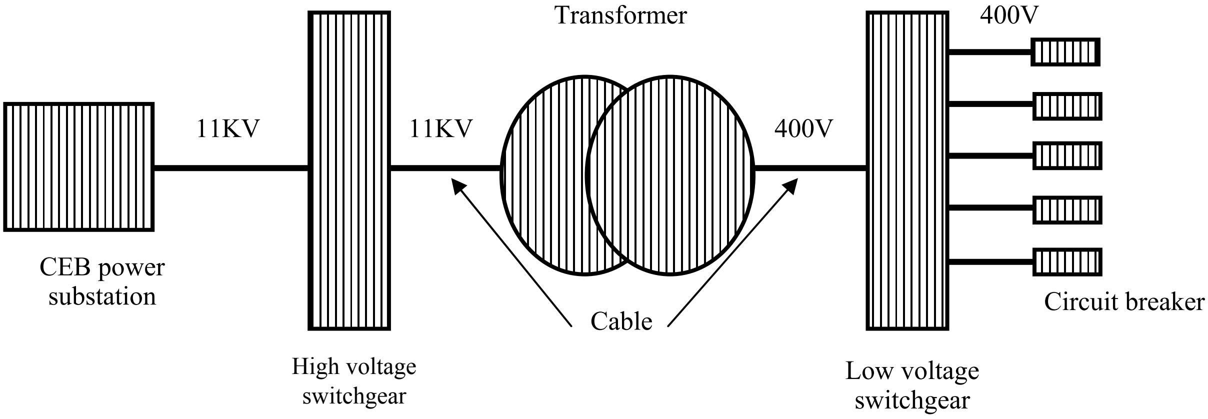

Figure 1: Electrical Power Distribution (Source: Kazibwe and Sendula, 1993, P.10)

2.1.1. POWER SUB-STATION

Electricity is generated in the power station alternator at 25kV. This electrical energy is fed into a transformer to be stepped up to a very high voltage for transmission on the grid network at 400kV, 275kV or 132kV. The electricity leaves the local sub-station and arrives at the consumer's mains intake position (Linsley, 2007).

2.1.2. HIGH VOLTAGE SWITCHGEAR

High voltage power supply directly comes to the high voltage switchgear. It works as the main safety component of the total electrical distribution and power levels and voltages rapidly escalated, making open manually-operated switches too dangerous to use for anything other than isolation of a de-energised circuit (Harrison, 1996). Oil circuit breaker, vacuum circuit breaker and gas (SF6) circuit breaker can be identified in the high voltage switchgears.

2.1.3. TRANSFORMERS

A transformer is device, which use to phenomena of the mutual induction to change the values of alternating voltages and currents and in face one of the main advantages of the AC transmission and distribution is an alternating voltage can be increased or decreased by transformers (Harrison, 1996). This component is used in the electrical distribution to step down the high voltage in to the low voltage.

2.1.4. LOW VOLTAGE SWITCHGEAR

Harrison (1996) explained, low voltage switchgears (fuses, air blast circuit breaker, minimum oil circuit breaker and oil circuit breaker) use after converting the high voltage current to the low voltage current. Main function of low voltage switchgear is protection, which is interruption of short-circuit and overload fault currents while maintaining service to unaffected circuits. Switchgear also provides isolation of circuits from power supplies.

2.1.5. ELECTRICAL SERVICE SHAFT (CABLES AND ENCLOSURES)

Power and lighting circuit conductors are contained within cables or enclosures. Part 5 of the IEEE Regulations (2008 cited Linsley, 2007) explained that electrical equipment and materials must be chosen so that they are suitable for the installed conditions, taking into account temperature, the presence of water, corrosion, mechanical damage, vibration or exposure to solar radiation.

2.1.6. CIRCUIT BREAKERS

A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow (Weedy, 1972). Mainly circuit breakers are installed in the electrical distribution for the protection of equipments.

2.2. RISKS ASSOCIATED WITH THE ELECTRICAL POWER DISTRIBUTION SYSTEM

Risk is the potential that a chosen action or activity (including the choice of inaction) will lead to a loss or an undesirable outcome (Booty, 2006). Depending on the building or type of operation, electrical failure can cause a loss of goods, data, equipment, property damage, potentially even life that will require unbudgeted time and money to repair or replace, if possible (McPhee, 2010). Just because everything is working today doesn’t necessarily mean that potential problems aren’t there. The more power the building operation uses, the greater the risk of failure and the warning signs of these risks are invisible to the untrained eye. If it is left unchecked, failure happens suddenly and the results can be catastrophic (Chan *et al.*, 2001). Therefore, it is critical for the reliability of the EPDS operate without any failures. However, number of researches identified that EPDS can face with several risks which can be discussed under maintenance risks, operational risks, asset specific risks and human errors (Yu and Chan, 2005; Schneider *et al.*, 2006; Michel *et al.*, 2009).

2.3. MAINTENANCE RISK

According to Lam (2006), when a building is put to use, its building services including the EPDS must perform its operations in an efficient and effective manner round the clock during the life-span of the said building. Therefore, to attain optimum levels of efficiency, all service systems require both proper design and proper maintenance. However, as Narayan (1998) has pointed out, improperly maintained systems will deteriorate over time, increasing the likelihood for malfunction. For example, normal electrical cycles create thermal expansion and contraction that naturally loosen, connections, accumulated dust and dirt can produce a high resistance path (these paths are responsible for more than 30% of all electrical failures annually), moisture is another culprit that causes 17% of all electrical failures (McPhee, 2010). Therefore, risks can arise due to improper maintenance of the EPDS.

2.4. OPERATIONAL RISK

Operational risk can be identified as mistakes in process or procedure that cause losses (Chapman, 1997). According to Flanagan and Norman (1993), operational risks which affect the EPDS can be identified as staff unawareness, management systems failure, technology failure, model failure, technology obsolescence and inadequate internal controls. For example due to lack of awareness a staff member can trip a circuit breaker in the electrical distribution which can result in part of the building to lose power (Flanagan and Norman, 1993).

2.5. ASSET SPECIFIC RISK

According to Schneider *et al.* (2006), asset-specific risks mostly occur at the stage of selecting equipment or components of the EPDS since selection is the key to the life-cycle of assets. According to the explanation of BPA Manual (2009), asset risks of an electrical distribution system typically include;

- Risk of system or system component failure
- Risk of capacity inadequacy
- Risk of equipment/component/system obsolescence
- Risk of environmental damage or noncompliance
- Risk of security breach or noncompliance
- Risk of health issue or safety injury

Accordingly, risk of system or system component failure risk of capacity inadequacy, and risk of equipment/component/system obsolescence can be identified as risks which directly impact the failure or malfunction of the EPDS.

2.5. HUMAN ERRORS

According to Hollengel (1983), human error cannot be considered as a function, an activity, nor the result of an intention. It is simply a contradiction of any reasonable definition to say that a person can make an error intentionally. According to Dahlgaard *et al.* (2008), human errors may become a serious risk factor in the engineering service. They also point out how a system can fail due to a minor error on the part of the human. Therefore, human errors can be considered as a major risk factor that affects the continuous operations of the EPDS.

3. GAP IN KNOWLEDGE

Electric power is at the root of almost every services of a hotel building, yet electricity is almost always the most overlooked and under-appreciated utility in day to day operations of any building. Without it, almost everything stops, including the business. According to BPA Manual (2009), electrical losses continue to top the list as the equipment category with the most premature breakdowns, which cost business and industry through extra expense, disruptions and lost profits. According to literature findings studies have been conducted in determining what are the risks associated with EPDS in foreign context. However, the perception of risk is subjective while also being affected by the unique political, economic, environmental and cultural conditions of a country (Han and Diekmann, 2001; Andi, 2006 and El-sayegh, 2008). Also, no similar research has yet been carried out in Sri Lankan context in relation to risks associated with EPDS in relation to Sri Lankan hotels. Therefore, this research focused on investigating the risk factors that affect the electrical distribution system and mitigation strategies for the identified risks in relation to Sri Lankan hotel industry and finally aimed to develop a risk management framework for EPDS in Sri Lankan hotels.

4. METHODOLOGY

The study is of exploratory nature and requires an in depth understanding of risk in electrical distribution systems in Sri Lankan hotels, it has been argued that, when a phenomena of interest requires detailed in depth information, a qualitative research can provide distinctive advantages (Yin, 2003). Therefore, this research is based on qualitative research. The study resorted to the case-study method in order to study risk factors that affect the EPDS and mitigation strategies for the identified risks in relation to Sri Lankan hotel industry. Hence, the unit of analysis of the study will be 'risks in EPDS in hotel industry'. Three five star hotels were selected for the study based on access and time limitations (See Table 1). Interviews were the primary data collection technique in this study while organisational records such as guidance documents, registers, manuals, handbooks supplemented data-gathering efforts. Content analysis and cognitive-mapping techniques were used to draw conclusions.

Table 1: Details of Cases

Organisation	Case A	Case B	Case C
Type of Hotel	Five star City hotel	Five star Business hotel	Five star City hotel
Life span (Age) of the building	28 years	22 years	18 years
Interviewees	Maintenance Engineer	Assistant Chief Engineer	Assistant Chief Engineer
	Shift Engineer	Shift Engineer	Electrical Supervisor

5. RISK FACTORS ASSOCIATED WITH ELECTRICAL POWER DISTRIBUTION SYSTEM IN HOTEL BUILDINGS

5.1. INTERNAL RISK FACTORS

Figure 2 illustrates the main risk factors and sub-risk factors which were identified in the empirical study. The diagram was developed based on the data derived from the three selected cases. The findings show that there are four key risk factors affecting EPDS. Poor maintenance (maintenance risks), unplanned operations (operational risks), bad equipment (asset specific risks) and negligence (human errors) were identified as the main risk factors. Out of the four, the maintenance risk and unplanned operations were identified as the most critical risks which affect the EPDS because in all the three cases selected, identified poor maintenance and unplanned operations as critical risk factors. In addition, the asset-specific risk and human error were also mentioned by the respective interviewees.

According to the research findings, the maintenance risk depends on the different sub-risk factors. A poor maintenance plan, inaccurate maintenance strategies and failures in the maintenance schedule were identified as the main sub-risk factors in the case of the maintenance risk. The maintenance risk is also affected by some of the other common sub-risk factors. Low awareness, low level of training and unskilled persons was seen as the common sub-risk factors because most of them have a direct impact on all the main risk factors.

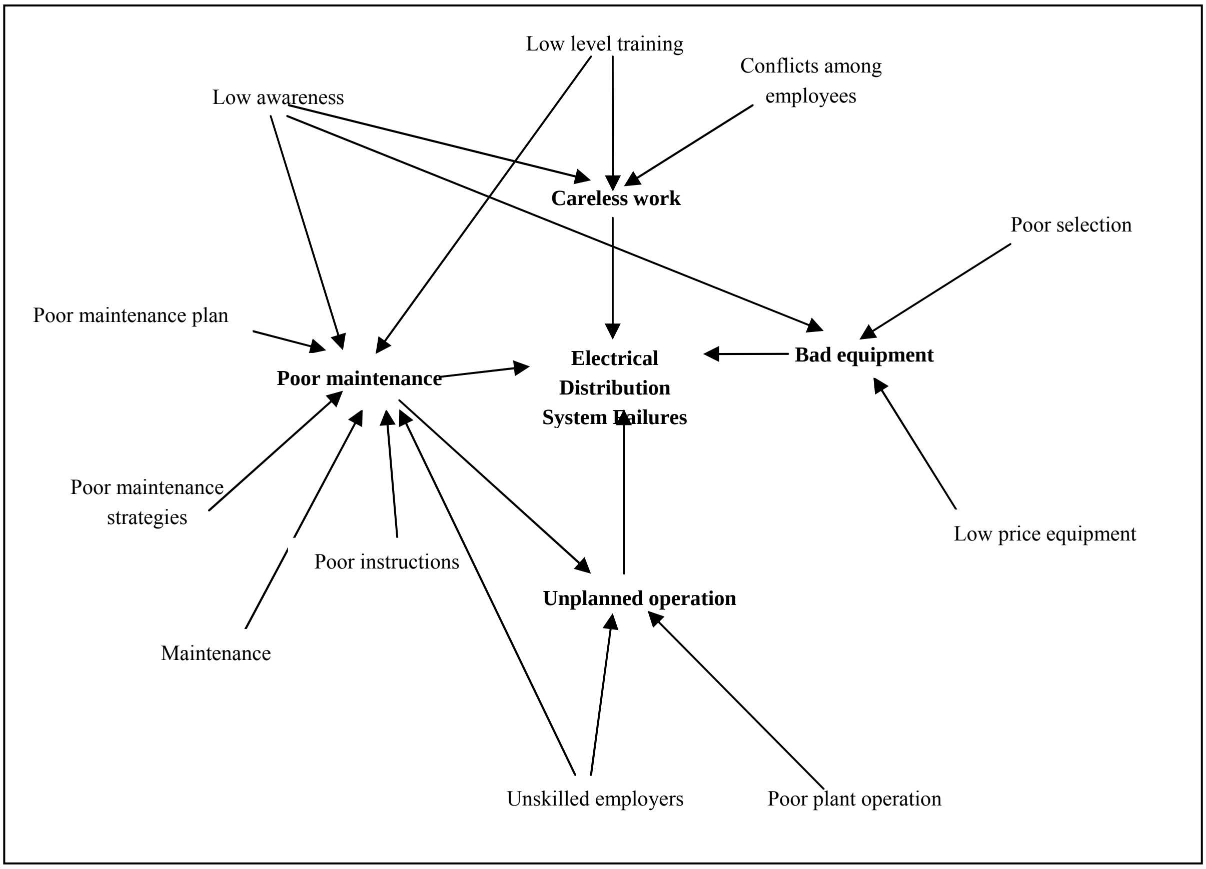

Figure 2: Different Type of Risk Factors which Affects the Electrical Distribution System

On the other hand, it was identified that some risks depend on another risk. For example, as the data shows, of poor maintenance may be the result unplanned operations.

5.2. External Risk Factors

External risk factors are another considerable fact which was identified through the interviews done by the researcher. External risk factors were emphasised by most of case representatives as the uncontrollable risk factor which they are faced during the operation. This point was emphasised by the representative of the Case A, "*weather condition may affect to the building services*". He emphasised whether condition as the uncontrollable external risk factors in the present situation. Further, he expressed that, "*mainly electrical system affect by the weather condition. High moister situation may cause to short circuit*". EPDS are highly sensitive to moister condition because it may spark due to higher moister situation. Therefore, weather condition directly affects the EPDS and it can cause to failures in the hotel EPDS.

5.3. Highly Risky EDS Components

The case study findings revealed that there is highly risky equipment in the EPDS. Representative of the Case A identified transformers and generators as high risk equipment in the system. Further, he stated that, "*transforms can fail due to the small changes in the moisture condition and generator can fail due to the irregular maintenances*". With respect to the ideas of the Case B Representative, "*MCCB and generators are high risk equipment in the electrical distribution. MCCB are fail due to the very small problem in the voltage*". He further stated that, "*because of the high risk in the generators, we have an agreement with the generator company to do the generator maintenance and related services*". According to the representative of case C, "*High voltage switchgear and generators are the high risk equipments in the electrical distribution. High voltage switchgear can be easily failed due to the spark and heat of the switchgear*". He further explained about the maintenance and service procedure, which was required for the proper operation of the system. Based on the empirical data, it can be identified there are components in the EPDS which can fail easily due to factors such as changes in moisture conditions or slight change in voltage.

6. MITIGATION STRATEGIES OF RISKS IN ELECTRICAL POWER DISTRIBUTION SYSTEM

The empirical data gathered revealed several risk mitigation strategies namely; mitigation strategies for maintenance risk, operational risk mitigation strategies, mitigation strategies for bad equipment and mitigation strategies for careless work. These will be discussed in the following section.

6.1. MANAGEMENT STRATEGIES FOR MAINTENANCE RISK

According to the empirical data poor maintenance can be identified as a key main risk factor which affects the EPDS. Therefore, maintenance schedule comprising with preventive and predictive maintenance strategies is a good way to prevent the occurrence of maintenance related risks. As an example representative of the Case B stated "*we follow preventive maintenance schedule to prevent any failure of the building services including EPDS. Preventive maintenance was done for the electrical system weekly, monthly and yearly*". Further, he clearly mentioned that, special testing called "hot pot tests" for maintain the main point of the electrical system is used. It is evident that having preventive predictive maintenance schedule to control maintenance risk is important. According to empirical findings maintenance system should be capable of preventing any fault which occurring due to the maintenance activities.

6.2. MANAGEMENT STRATEGIES FOR OPERATIONAL RISK

Operational risks are one of the critical risk factor which causes to fail the EPDS. According to the collected data, different management strategies are used to avoid the operational risk which occurring in the EPDS. Representative of the Case A emphasised that, "*each and every function in the hotel is done with the proper plan*". Representative of the Case B explained the importance of the proper plan. For example Most of the instances electrical power distribution system overloads due to the unplanned operation. He stated that, "*we identify the maximum load which can be able to bear in the each switchgear. Then we train people to consider about maximum load in the operation. It helps to prevent the operational risks of the system*". According to that, unplanned operations are identified as the main problem and proper planning is identified as the most suitable strategy for controlling the risk.

6.3. MANAGEMENT STRATEGIES FOR BAD EQUIPMENTS (ASSET SPECIFIC RISK)

Empirical findings showed that there are asset specific risks in relation to EPDS Although, The interviewees are more concerned about this issue and suggested management strategies for this risk factors. According to the explanation of the Representative of Case A, "*when we are selecting equipments; we go for the best equipment in the industry. It can help in preventing failures due to faulty equipment*". In addition the empirical findings showed proper equipment selecting criteria should be adapted to avoided asset specific risk.

6.4. MANAGEMENT STRATEGIES FOR HUMAN ERROR (CARELESS WORK)

According to empirical findings most of representatives emphasised that, human error was difficult to manage with strategies because; most of the human errors happen due to personal attitude. Representative of the Case A stated that, "*we have training programs to educate the people to manage the emergency situation without any problems*". He emphasised that, people are educated with the use of training programs. With respect to empirical findings, employees training and development were identified as the management strategy for the human errors.

7. THE RISK MANAGEMENT FRAMEWORK FOR ELECTRICAL POWER DISTRIBUTION SYSTEMS IN SRI LANKAN HOTELS

The aim of this research was to develop a risk management framework for EPDS in Sri Lankan hotel industry. As the research findings revealed, once the risks were identified, they can be addressed via the risk management framework. The developed risk management framework for EPDS is as illustrated in Figure 3. It was developed based on the research findings and the analysis of data generated through the literature review, interviews and the review of organisational records of the selected cases.

The first and second objectives of this research were identifying the key building services in hotel buildings and identifying the risk factors associated with the failures of building services. These objectives were achieved through the literature review. The third objective was to identify the risk factors related to EPDS failures in hotels in the Sri Lankan context while the fourth objective were to identify the strategies used for mitigating the risk factors associated with EPDS failures. These objectives were achieved form the data which were gathered through interviews and organisational records of the selected cases. The final outcome of this research was to develop a risk management framework in terms of EPDS which was realised from the critical analyse of the literature and interviews details (See Figure 3).

According to empirical data the maintenance risk, operational risk, human error and asset-specific risk were identified as the internal, controllable risk factors. In addition, weather condition considered as external uncontrollable risk factors. The risk management framework uses different strategies to minimise the internal and external risk factors. The research findings showed the failure mode effect analysis method as the most appropriate tool for use in the risk identification process. According to a representative of case B the results from the failure mode effect analysis can provide the required risk management strategies to control the effect of failure. Therefore, in the proposed risk management framework, this method is recommended to prioritise and evaluate the risk factors in the building services.

The risk management strategies were identified as offering control methods for internal risk factors. As explained by a representative of Case B after identifying and prioritising the risk factors through the failure-mode effects analysis method, risk management strategies were used to control the risk factors. For example preventive predictive maintenance schedule, planned operations, employee training and asset-selection procedures were identified in the research findings as the main risk management strategies in EPDS. However, according to the interviewees uncontrollable risks such as changes in weather were difficult to control through the risk management framework.

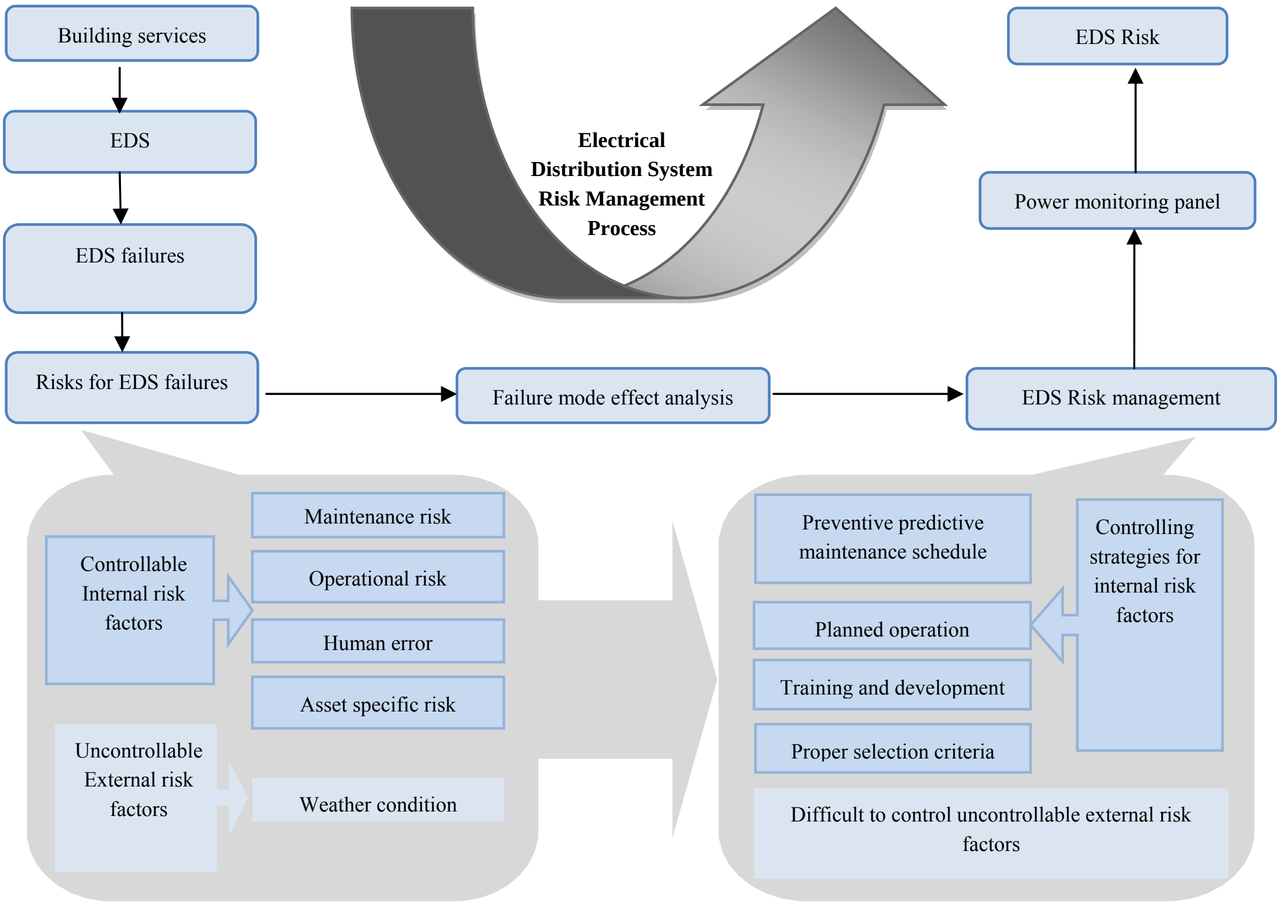

Figure 3: Proposed Risk Management Framework for Electrical Distribution System

Monitoring the process implemented is an important aspect in any system. According to empirical data, the power monitoring panel was identified as the monitoring method most used in the electrical EPDS risk management framework. According to the explanations offered by representatives of Case C and Case A, the power monitoring panel helps them to identify the location of the fault and to provide mitigation strategies for the fault.

The reactive risk management strategies may not be enough to control risks that occur in EPDS. According to a representative of Case A, it is necessary to have a pro active as well as reactive risk management system as the hotel is responsible in providing uninterrupted and quality service to their customers. Some failures can also occur due to external uncontrollable risk factors. Therefore, a pro active risk mitigation plan was emphasised as the final step in the risk management framework. The research findings emphasised that a risk mitigation plan addressing different aspects was required to manage emergency situations. Each and every critical aspect of the system is addressed in the risk mitigation plan in order to control the damage due to the failures.

8. CONCLUSIONS

The prime aim of this study is to develop a risk management framework for EPDS in Sri Lankan hotel industry. Since guest satisfaction was identified as the most important consideration in a hotel, continuous operation of the different building services has to be assured. From the many different building services installed in a hotel building EPDS was identified as the key building service because the operations of all other services depend on the EPDS. Thus, power failure would inevitably lower guest satisfaction.

Both the literature review and interview data revealed the different risk factors associated with EPDS. These risk factors were categorised as internal and external in the interview data. While the maintenance risk, operational risk, human errors and asset-specific risks were identified as the main internal controllable risk factors, weather conditions was identified as the uncontrollable external risk factors.

The final objective of this research was to develop a risk management framework for EPDS in the hotel industry. Based on the research findings, a risk management framework was developed as shown in Figure 3. The proposed risk management framework was developed addresses the risks in the EDPS in the hotel. The risk management framework comprises the failure-mode effect analysis, risk management strategies, power monitoring panel and risk mitigation plan. It should also be noted that each and every step addresses critical points in the risk management process of EPDS. The findings and recommendations of this study will be useful to those responsible for EPDS operations in the hotel industry for the purpose of reducing EPDS failures.

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