

# Risk Methods Applied to Electricity Distribution System in the UAE Electricity Markets



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**Abstract:** Electricity distribution systems (EDSs) are essential pieces of infrastructure for nations worldwide. However, the key assets constituting these systems can be exposed to various forms of risk. The purpose of this research was to explore and explicate the risk management methods applied to electricity distribution system asset management in the United Arab Emirates (UAE) electricity markets. It was a secondary research that encompassed the use of the existing data to explore this issue and address the research questions. The research findings revealed the electricity distribution system asset management exists in the form of real time, mid-term, and long-term. Moreover, it was found that this system could be exposed to economic, environmental, quality, reputational, vulnerability and regulatory risks. Finally, the research findings revealed risk management methods that could be used to the system in the UAE electricity markets are categorized as simplified, standard, and model-based. This study recommended that UAE companies operating in the electricity industry should apply a holistic risk analysis in their electricity distribution system asset management.

**Keywords:** electricity distribution system, risk management, asset management, UAE.

## I. INTRODUCTION

Electricity distribution systems (EDSs) are essential pieces of infrastructure used by the modern society. Francis and Skitmore (2005) indicate that these systems entail a sense of the provision of precision engineering solutions. These are solutions that range from cable fault location services to live line capacity. Thus, this entails the application of engineering skills, including design, construction, and operation, as well as maintenance of infrastructure networks. Furthermore, Francis and Skitmore (2005) explain these networks are composed of distribution lines, which can be underground and overhead, protection and control systems, and high voltage electrical stations. The operation of the systems entails receiving power at high voltage. This takes place through transmission networks from the generators, which is then reduced to a low level that is suitable for the requirements of a given distribution station. Moreover, it is

imperative to indicate that the management of these systems tends to entail striking some kind of balance between cost and risk. According to Nordgård, Sand, and Wangenstein (2009), the above-indicated measure should be done while considering varying concepts that include economic performance, environmental impact, and supply quality. It is worthwhile noting that these concepts tend to comprise the conflicting forms of objectives within the decision-making process.

Asset management of electricity distribution systems is a method that many companies apply in order to balance risk and cost. Khuntia, Rueda Torres, Bouwman, and van der Meijde (2016) explicate, more electricity distribution companies are currently gaining a sense of awareness of how to handle different emerging risks for their systems of electricity distribution. Therefore, in the course of asset management, understanding and managing risk are considered vital issues that distribution companies are currently facing. This paper focuses on effective risk management methods applied to electricity distribution system asset management in the UAE electricity markets.

## A. Background of the Research

Electricity distribution can be defined as a form of natural monopoly. Nordgård et al. (2009) explain that this definition refers to electricity distribution based on the reasoning that it is not a socio-economic efficient decision to create compelling parallel infrastructures in order to provide electric services. Thus, in order to ensure that there is no rise in the abuse of power that emanates from the monopoly, there are strict regulations by the concerned authorities.

In the UAE, the electricity distribution market is placed under the energy sector. It is rated as one of the fastest growing electricity markets around the world. Furthermore, this market contributes substantially to the country's gross domestic product (GDP) (Agrawal, 2016). This has been of great significance in enhancing the social and economic development of the UAE. One of the recent trends within this market is a forecast increase in power generation. Particularly, the UAE had undergone a 1.5 gigawatts increase by 2017 (Agrawal, 2016). This increase is considered adequate to enable the powering of the estimated 150,000 home regions (Agrawal, 2016). A factor that has contributed to this great performance is the UAE's increased use of mixed energy sources. These sources comprise natural gas, nuclear power, and solar power.

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Thus, with this form of performance, the UAE plans to reduce power import, as well as work towards energy sustainability. For instance, Dubai Electricity and Water Authority (DEWA) has been responsible for generating, transporting, and distributing water and electricity within Dubai (Agrawal, 2016).

Another authority that has also been carrying out this responsibility is the Federal Electricity and Water Authority (FEWA). This authority supplies water and electricity to the emirates of Sharjah, Umm Al Quwain, Ajman, Fujairah, and Ras Al Khaimah (Agrawal, 2016).

Over the last few years, there has been the substantial number of changes in the electricity distribution sectors in different parts of the world, including the UAE. This tendency has resulted in the transformation of this industry from a highly protected one to one that is exposed to a high sense of efficiency requirements. For the UAE, electricity requirements are determined by the structure of the government, as well as powers that each individual emirate has (Agrawal, 2016). These requirements have included the application of benchmarking that has been enabled through the monopoly regulation of electric distribution (Nordgård et al., 2009; Nordgård, 2010). This has significantly contributed to the improvement of efficiency throughout the industry. The improvement has inspired the majority of electricity distribution companies to increase their efforts in order to create much more efficient ways of doing business. Companies put effort in gaining a competitive edge as determined by the practices implemented by regulatory authorities.

The key trend that has emerged from this need for improved efficiency is asset management. Therefore, many electricity companies, including the FEWA and the DEWA operating in the UAE electricity market, are currently using asset management as a guiding principle for doing business. Today, asset management is an area of business that has emerged from a number of industries. All these industries emphasize the significance placed on the infrastructure of physical assets (Nordgård et al. 2009). Asset management is a practice that covers a wide range of concepts within distribution system planning and operation (Nordgård et al., 2009). Therefore, risk management is referred to as a factor that is of great relevance in this regard.

### B. Research Problem

Electricity distribution systems have become highly complicated. Shariati and Yazdani-Chamzini (2014) indicate that the complex nature of these systems require high skilled resources. Moreover, this nature requires the development of a reliable asset management approach that will be essential in the protection of various forms of risks that the system could be exposed to.

In reference to the case of the UAE, the electricity distribution system is undergoing the time of rapid change. According to Agrawal (2016), this change comes about as a result of the high growth of population in the UAE. It is imperative to note that the current number of people living in the UAE has exceeded the number forecast a few decades ago. This tendency has led to constructing distribution entities due to the need to meet a high demand for electricity.

Furthermore, the above-mentioned tendency has resulted in different concerns about the effects of this demand on the quality of distribution management. Consequently, questions concerning the degree to which risk management is practiced by electricity distribution companies have also been made emphasis on.

There is very minimal coverage of the manner in which risk is practiced in high-risk industries, such as electricity distribution. For instance, Burchett et al. (1999) conducted their study on this issue almost two decades ago by (as cited in Nordgård et al., 2009). According to the research findings by Burchett et al., the extent of the use of risk management depends on the concern by managers about time involvement, the understanding of quantitative techniques, and organizational resistance.

### C. Rationale and Significance of the Research

The rationale for this research is in the need to improve electricity distribution in the UAE by finding effective risk management methods that would allow applying electricity distribution system asset management. Thus, the lack of information of this form of risk management is reducing the degree of the efficiency of electricity distribution companies in carrying out their operations. Moreover, the rationale for this study is based on identifying a novel approach that could be used to facilitate a high level of performance in the electricity sector of the UAE by implementing methods of risk management.

Accordingly, understanding the risk management methods within this context will be useful in enhancing the quality of services that are provided to citizens of the UAE. Furthermore, the significance of this research is to contribute to knowledge in this field by enabling further exploration of the risks faced by electricity distribution system asset management within the UAE electricity markets.

### D. Research Aim and Objectives

The aim of this research is to investigate and explicate the risk management methods applied to electricity distribution system asset management in the UAE electricity markets. The objectives of the study include:

- To analyze the electricity distribution system asset management in the UAE electricity markets;
- To establish the risks that electricity distribution systems face in the UAE electricity markets;
- To identify some of the risk management methods applied to electricity distribution asset management in the UAE electricity markets.

### E. Research Questions

The research questions are as follows:

- RQ1: What is the electricity distribution system asset management in the UAE electricity markets?
- RQ2: What are the risks that electricity distribution systems face in the UAE electricity markets?
- RQ3: What are some of the risk management methods applied to electricity distribution systems asset management in the UAE electricity markets?

## II. LITERATURE REVIEW

### A. Introduction

The main aim of establishing an electricity distribution system is to provide people with reliable electricity services.

However, the provision of such services needs to be done in a cost-effective manner. This goal can become a real challenge given the complex nature of the electricity distribution system. Thus, it is imperative that the utilities should not only satisfy quantitative reliability requirements but also reduce cost. Furthermore, the risk to this system goes beyond cost and encompasses a number of components. Therefore, the literature review is aimed at assessing the existing studies on risk management in electricity distribution system asset management and how it relates to the electricity markets in the UEA. The review of literature begins with the assessment of risk and its occurrence in an electrical distribution system. The, the analysis of risk management will be conducted. It is worthwhile indicating that asset management is assessed as a concept and the last section of this literature review is devoted to analyzing how it is facilitated in electrical distribution systems.

### B. Risk and Electrical Distribution System

There are a significant number of risks that electricity distribution systems are exposed to. Thus, electricity distribution companies around the world, including those in the UAE, acknowledge there are a variety of risks that they face.

Risk can be understood by referring to the definition provided by the ISO (2006) and IEEE standard as "The combination of the probability of an event and its consequence" (as cited in Jalili, Khomami, & Firozabad, 2011). In this case, event is defined as the occurrence of a given set of circumstances. Probability is defined as a degree to which an event will take place. Consequence can be understood as an outcome of a specific event.

Risks are a topical issue for electrical distribution systems due the significance of these systems to society as a whole. The risks that electrical distribution systems are exposed to are divided into three key categories (Nordgård et al., 2009). The first category comprises the risks that relate to breaking environmental / safety laws. The second category includes the risks of outages that impact cost in the form of customer compensation and damage. The final category comprises the risks of events that can result in cost of repair with the absence of customer outages.

### C. Risk Management

Nordgård et al. (2009) assert the significance of risk management as it can be used in order to prevent the occurrence of different undesired events. Therefore, risk management is undertaken in electricity distribution system asset management in the UAE to prevent the occurrence of various undesired events. According to Moja, Van Zuydam, and Mphephu (2016), electrical engineers have the responsibility of overseeing the maintenance of distribution networks and their reliability. This can be done by means of effective and efficient preventive maintenance strategies. While electricity distribution systems have large equipments

within the network, there are various faults that can take place. Khaliq, Mahmood, and Das, (2015) indicate that different faults usually result in interruptions, which can subsequently increase chances of occurrence of system risk. Therefore, there is a need for carrying out maintenance tasks in order to prevent the occurrence of different faults. However, budget limits tend to be an issue that can hinder the prevention of these faults as companies are unable to undertake the maintenance.

Risk management is essential for an electrical distribution system (Ioannou, Angus, & Brennan, 2017). According to Agrawal (2016), within public sector organizations like those that are involved in electricity distribution (the DEWA and the FEWA), exposure to risk and various accompanying effects are functions of the cultural environment framework within which they operate. In addition, literature looks into the significance of undertaking risk management within the electricity distribution market. Spikin (2013) states, the need to ensure safety is one of the reasons as to why risk management is necessary.

The definition provided by Nordgård et al. (2007) illustrates an overall frame of the significance of risk methods in electrical distribution systems, which are an essential aspect of risk management. However, these methods lack specificity as they present the methods using a wide perspective. There is a discussion between risk concepts applied in the EDSs that demonstrate a connection between risk and reliability. A good example is in the notion that a higher customers' outage represents a lower sense of distribution reliability and vice versa. At the same time, some studies suggest the use of reliability assessment in risk management (Spikin, 2013). In this case, risk assessment should be undertaken while considering the factors of event, probability, and consequence.

One of the most common methods applied in the assessment of risk is risk matrices. A good example of the use of these methods is the electrical distribution systems in Sweden (Francis & Skitmore, 2005). This method entails first estimating the probability and consequence of risk into the settled categories that have been determined either qualitatively or quantitatively. The categories result in the formation of two axes that have a two-dimensional matrix. The matrix has estimated risk values or some proposed action measures (Francis & Skitmore, 2005).

Unlike other systems, electrical distribution systems possess exceptional characteristics that should be considered in the course of determining the risk management methods that will be used. Kozhevnikov, Gitelman, Magaril, Magaril, and Aristova (2017) emphasize that one of the factors that should be considered is the dependence of the entire society on this system. The fact that electrical distribution systems tend to be operated based on the local regulated monopolies should be taken into account while developing risk management methods. Furthermore, the link of electronic distribution systems to other electrical systems, like load points and supply points, should also be considered.

## D. Asset Management

Nordgård et al. (2009) establish that asset management comprises two elements: the management of organizational aspects and the management of physical infrastructure.

In this paper, focus is placed on the management of the asset of physical infrastructure relating to electricity distribution systems.

There are various understandings of asset management that have been presented in literature. Al-Batayneh and Al-Mehairi (2014) emphasize the optimum manner of managing assets to achieve the outcomes that are desired and sustainable. This definition does not necessarily expound on what asset management is; though, but it reveals the detail of managing assets in such a manner that it is possible to achieve the desired outcomes that are sustainable, meaning long-lasting.

A more comprehensive definition of asset management is, the systematic and coordinated activities and practices carried out by organizations with the intent of optimally managing assets, including performance and risk over a period of their life-cycle (Nordgård et al., 2009). This definition provides additional concepts of asset management that are optimal management of assets and coordinated activities and practices. However, just like the previous definition, there appears to be little explication regarding the concept of asset and management.

A more appropriate definition of asset management is provided by Nieto, Amatti, and Mombello (2017). Researchers indicate that asset management involves opportunities, balance costs, and risks against the desired performance of assets so as to predict the realization of organizational objectives. Therefore, the above definitions of asset management indicate, risk management remains a well-integrated aspect of this concept. There is a call for some form of continuous improvement. Nordgård et al. (2009) state, risk management is an essential part of the asset management process for continual improvement.

The significance of asset management includes enabling organizations to gain insights into the need for assets, asset systems, as well as their performance at different levels (Nieto et al., 2017). Moreover, it is equally significant because it allows for the application of analytical approaches to the management of assets across varying stages of product lifecycle. This can take place from the moment of conception of an asset all the way to its disposition. In addition, it can also include the management of any potential obligation following the disposal of the asset.

## E. Electricity Distribution System Asset Management

According to Nordgård et al. (2009), asset management in the electricity distribution sector has been serving as an essential guiding principle for business performance. For instance, the UAE has been able to encourage electricity distribution companies to work towards becoming certified. Asset management is essential for electricity distribution companies as it enables the development of competence. Furthermore, it is further significant towards fostering a means towards long-term asset risk management (Wallnerstrom & Bertling, 2009). Asset management is also useful in enabling the establishment of a greater sense of the

clarity of processes and policies underpinning the key decisions made concerning asset investment.

According to Nieto et al. (2017), electricity distribution systems tend to consist of electrical devices that are used for the purpose of switching and protection, medium voltage lines, low voltage lines, and various other useful components. Furthermore, these systems comprise transformation sub-stations, which may be aerial, underground, or level and are distributed along a given geographical area. Therefore, a significant amount of investment is made in the course of developing these systems. Asset management as it relates to these systems can take place in the form of short-term, medium-term, and long-term. Accordingly, the short-term asset management of electricity distribution systems entails undertaking some form of real time operations. Medium-term asset management is done in order to assess the key aspects relating to the remaining life and handling of investment. Long-term asset management concerns the development of scenarios that relate to information analysis to enable asset renewal decision-making.

## F. Summary

The above review of literature was insightful in illustrating details into essential aspects of the research problem under investigation. The review indicated that electricity distribution systems are complex networks whose management has to be done carefully when it comes to protecting against risk. According to the literature review, risk is a likely occurrence for the electricity distribution systems. This tendency reaffirms the need to have effective risk management methods. This review also showed that asset management is essential in fostering the protection of physical infrastructure. It entails adopting a system of activities and practices by the electricity distribution companies in the UAE to ensure that their assets used for the electricity distribution systems are well managed.

## III. METHODOLOGY

### A. Introduction

In this section, the key methods of research that were applied to this study are provided. The methods and the rationale for their application are discussed in this research. Particularly, the research type, data collection, and data analysis methods used to carry out the study are discussed in detail. Moreover, the ethical issues considered in the course of conducting the study are indicated. Limitations relating to the methods used and how they were addressed so as not to have any severe impact on the research results are equally discussed in this section.

### B. Research Type

A secondary research involved the application of the existing data on the key components of the research topic and problem of this study. Thus, the problem of risk management methods that are applied to electricity distribution system management in UAE electrical markets was investigated and explicated utilizing the data gathered from previous studies.

Therefore, it was essential to carefully analyze any study whose purpose was close to the issue that the present study aimed to address (Curtis, 2018).

However, in the course of applying this research type to this study, consideration was given to the fact that the existing data may have been collected for the issues other than what was being explored.

Therefore, Johnston (2014) explicates that it is essential to ensure that the data was used in a manner that was in line with the current issue under investigation.

One of the main reasons that influenced the use of this research type for the present study was it saved on time to undertake it given that the needed data to address the research issue already existed as asserted by Johnston (2014). Thus, this fact allowed conducting this research within a much shorter time and hence investigating and explicating the risk management methods applied to electricity distribution system asset management in the UAE electricity markets. This research type was also used as it was cost effective. Hence, there was no need to invest any extra money since the needed data has already existed. Nonetheless, a small amount of cost was incurred in accessing some of the studies that were used as they were taken from the protected databases that require payment for access. According to Johnston (2014), secondary data is easy to use and access. Thus, the ease of access of secondary data further influenced its usage in this study. It is worth noting that due to the present technological development, this type of data is stored in an electronic format and is already cleaned. According to Curtis (2018), this fact becomes an advantage because it results in less time taken for accessing and assessing the collected data since it does not require any preparation before use. Moreover, the sheer amount of data on the research issue, which is available, is quite considerable, and thus, its usage is justified (Johnston, 2014). Thus, secondary research tends to be used when the amount of data that is available on the issue under study is quite considerable.

### C. Data Collection

One of the main factors that should be considered in the course of collecting the secondary data used in this study was the method of data collection. Particularly, Johnston (2014) indicates that it is essential to verify the validity of the factors, which ensured the validity of the data. Furthermore, the aim and objectives of the studies where the data was derived from was yet another essential factor that should be taken into account. Thus, data collection encompassed screening the derived studies from online research databases and determining the degree of relevancy to the research problem under study. The screening process implied assessing the titles of the studies determining only relevant ones. The next step was aimed at reviewing the abstracts once again resulting in the elimination of studies that were not relevant (Curtis, 2018). The final step was conducting a full review of the remaining studies taking note of the key aspects that related to the research problem.

### D. Data Analysis

The interpretation of the data collected from different secondary sources was done utilizing a content analysis

method. According to Curtis (2018), this method of data analysis encompasses the interpretation of data by making inferences that are replicable and valid. This is further achieved through coding of textual-based material that can include books, reports, and peer-reviewed articles. Therefore, the application of this data analysis method allowed for a systematic evaluation of the collected data derived from the secondary sources. The following measure led to identifying the emerging themes related to the problem of risk management methods applied to electricity distribution system asset management in the UAE electricity markets. Therefore, with these themes, it was possible to make inferences of the research problem.

### E. Ethical Considerations

Research ethics remain of relevance despite the fact that this study lacked human subjects. The significance of research ethics in this regard is to ensure the accuracy of the collected data and key conclusions that are reached following that. Therefore, a number of ethical considerations were taken in respect to the above-mentioned issues. Therefore, confidentiality is one of the ethical issues that were taken into consideration. Since this study was secondary in nature and did not involve the use of human subjects, confidentiality remained essential. Confidentiality ensures that the identity of those participants that provided data for the secondary studies that were used in the present study was well protected (Tripathy, 2013). Therefore, it was imperative to be careful with all instances in which key identifiers of these participants, including names, residency, and workplace, and positions, could be seen because they could be used to identify them.

Consent was equally an ethical issue that was taken into consideration. Once again, this was not taken in the conventional manner that is done within primary data. According to Tripathy (2013), consent is of relevance in relation to secondary data because it ensures that the data that was collected and used in this study was consented to be used in this manner. Thus, studies that were readily available in online databases for academic usage were referred to. Such availability indicated the consent for their use in this manner. For other studies, it was necessary to contact the authors for consent to use their work.

Another issue concerned publication. It is worth indicating that this study was carried out to achieve academic objectives alone and not for profit-based objectives as explained by Curtis (2018). Therefore, the work will be published to further academic growth in the field of study and not to profit the researcher.

Plagiarism is yet another key ethical issue that was considered in this study. Tripathy (2013) opines, this involves the academic misgiving of the use of other researchers' work as one's own or referring to their work without crediting them. This ethical issue is quite prominent in the present study because of the use of secondary data.

However, this issue was prevented by a comprehensive process of citing all the works that the researcher referred to. Accordingly, in-text citations were done to indicate the study or research that was not conducted by the researcher (Tripathy, 2013).

Furthermore, a complete list of references of all the works used in this research indicated the degree to which other researchers were credited for their work.

**F. Limitations**

One of the limitations encountered in the course of using the research methods discussed in this section is the secondary data that was used was one which was not developed to address the given research problem. There was the possibility that the existing secondary data would not contain the specific data that could address the research questions in mind. Therefore, it was necessary to carefully examine the data before using it to ensure that it was in tandem with the research aim and objectives (Curtis, 2018).

Another limitation concerned the degree of the validity of the secondary data. This challenge derived from the fact that the researcher did not participate in the primary studies from which the data was collected. Therefore, it was not easy to determine with complete success the validity of some of the data that needed to be used. Thus, any data whose validity could not be adequately determined was disregarded for this study.

**G. Summary**

The methodology that was used for this study was based on the secondary research type. Therefore, secondary research methods were appropriate in conducting this study and addressing the research issue under investigation. Thus, the research questions were addressed using the already existing data collected by other researchers. This measure was beneficial due to the convenience it offered and the time it saved in conducting the study. However, the issue of validity was of great significance given that the researcher did not directly participate in the studies from which data was derived. Furthermore, this section demonstrated that this study placed efforts towards adhering to research ethics as demonstrated in ethical considerations discussed.

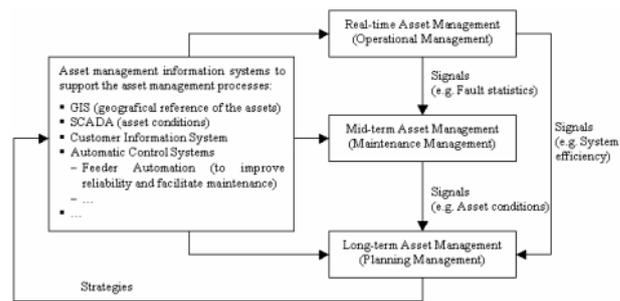
**IV. RESULTS**

The results of this study will emphasize the risk management methods applied to electricity distribution asset management in the UAE electricity markets. It is worth noting that research results are based on the secondary data collected from the related studies. The results will be presented in the form of addressing the research questions of this study. That is, the data provided in various related studies will be utilized to give answers to the set research questions. Accordingly, the results of this research are demonstrated below.

- Results to RQ1: What is the electricity distribution system asset management in the UAE electricity markets?

In their study, Tor and Shahidehpour (2006) defined the term “electricity distribution system asset management”. This definition focuses on the most significant aspects of the problem that this study sought to address, and hence, it may be

applied to electricity distribution system asset management in the UAE electricity markets. It is evident that electricity distribution system asset management is composed of the following key concepts represented in Fig.1.



**Fig. 1. Asset Management Strategies**

Source: Tor and Shahidehpour (2006).

Therefore, the diagram illustrated shows that asset management is real time, mid-term and long-term. Real-time asset management is done through operational management. Mid-term asset management is achieved through maintenance management. Long-term asset management is carried out through planning management.

- Results to RQ2: What are the risks that electricity distribution systems face in the UAE electricity markets?

The results regarding this research question are based on the study conducted by Nordgård et al. (2009). The results of this study provide insights into the key risks that electricity distribution systems in the UAE are exposed to. Accordingly, the results are demonstrated as in the diagram below.

**Table- I: Summary of Risks Faced by Electricity Distribution Systems**

Risk consequence categories	Risk impact			Risk analysis methods			Methods used
	Local	System	Corporate	Simplified	Standard	Model-based	
Economic / financial risk			+		+	+	NPV-analyses
Safety risk	+	+	+	+	+		Brainstorming, Risk matrices
Environmental risk	+	(+)	+	+	+		Coarse risk analysis
Quality of supply risk	+	+		+	+	+	NPV-analyses, Power system Analysis
Reputational risk	+		+	+	+		Coarse risk analysis, Risk matrices
Vulnerability risk		+	+	+	+	+	Coarse risk analysis, Risk matrices, Power system analysis
Regulatory risk			+		+	+	Coarse risk analysis, Risk matrices, Simulation (e.g. data envelopment analysis)

Source: Nordgård et al. (2009).

The above diagram demonstrates the number of categories of risks that the electrical distribution system faces. It is evident that there are economic, environmental, quality, reputational, vulnerability, and regulatory risks. According to the study findings, economic risks occur as a result of the possible loss of money (Nordgård et al., 2009).

Therefore, this kind of loss for the UAE electrical markets can come about as a result of electrical distribution companies higher cost than anticipated or loss. Quality risks are referred to the quality of electricity supply. Thus, different regulations have placed to ensure that the high level of quality is maintained.

Vulnerability risks relate to the system's lack of the ability to withstand the occurrence of unwanted risks, reduce the impact, and achieve stabilization (Nordgård et al., 2009). The safety risks entail danger occurrence to the occupational and third party safety. Environmental risks concern the impact that the distribution will have on the locals, including the sites that may be close to accidents emanating from electrical distribution systems. Reputational risks relate to loss of goodwill among stakeholders, thus impacting business operations (Nordgård et al., 2009).

- Results to RQ3: What are some of the risk management methods applied to electricity distribution systems asset management in the UAE electricity markets?

The answer to this research question is derived from the study conducted by Nordgård et al. (2009). Researchers managed to identify a great variety of risk management methods that could be applied to electricity distribution systems asset management. These methods are suggested for use for the UAE given the close nature of the research problem under investigation in this given study. Accordingly, the methods identified by Nordgård et al. (2009) are provided in the table below.

**Table- II: Categories of Methods of Risk Management.**

Category	Type of analysis	Description	Example of methods
Simplified risk analysis	Qualitative	Informal procedures that analyses risk using e.g. brainstorming sessions and group discussions.	- Coarse risk analyses - Brainstorming sessions
Standard risk analysis	Qualitative or quantitative	More formalized procedures in which recognized risk analysis methods are used. Risk matrices are often used to present the results.	- Risk analysis assisted by HAZOP - Risk matrices - Job safety analysis
Model-based risk analysis	Primarily quantitative	Formal methods using e.g. event tree analysis (ETA) and fault tree analysis (FTA) are used to calculate risk.	- Fault tree analysis - Event tree analysis - Reliability analyses - Bayesian networks - Electrical system simulation - Benchmarking methods

Source: Nordgård et al. (2009).

It is obvious from Table 2, there are three main risk management methods that could be applied to electricity distribution system asset management for the UAE. These methods are standard, simplified, and model-based risk analysis. The simplified risk analysis encompasses several informal procedures that analyze risk through such processes as brainstorming or holding some form of group discussions. The standard risk analysis provides a more formal method procedure, and thus, the recognized risk identification processes are used. One of these processes entails the use of

risk matrices to identify risk. The final method of risk management of model-based risk analysis entails the use of formal methods in order to identify risk. An example of this is evident in the application of fault tree analysis and event tree analysis.

## V. DISCUSSION

According to the results of the research, companies operating in the UAE electricity markets may apply various risk management methods to their electricity distribution system asset management. It is worthwhile indicating that the electricity distribution system asset management that can be used for the UAE electricity markets entails three main strategies, including real time, mid-term and long-term asset management. These results show that asset management as it relates to the electrical distribution system takes place, depending on the time frame. Thus, asset management can take place during real-time operations, remaining life of assets, and through adequate maintenance that can lead to the asset lasting for a long time. These results correlate with those by Nieto et al. (2017) who identified long-term, medium-term and short-term (real-time) asset management of electrical distribution systems.

The results of this study demonstrate that there is a variety of risks that electricity distribution system can be exposed to within the UAE electricity markets. The identified risks touched on key aspects of running this system that comprise cost, regulatory requirements, and well-being of the public, including safety, environmental and quality risks. Thus, the impact of these risks relates to the system, organization, and society.

Furthermore, the risk management methods applied to electricity distribution systems asset management that companies operating in the UAE electricity markets could utilize were identified in this research. In accordance with the research results, electricity distribution companies in the UAE electricity markets can apply both formal and informal methods of risk management to their electricity distribution system asset management. Accordingly, the identified methods of simplified, standard, and model-based risk analysis do provide some form of generic grouping regarding the varying categories of risk analysis. These results are in line with those by Nordgard, Nordgard, Gjerde, and Catrinu (2010) who develop a framework that could be applied to risk management based on distribution system asset management.

## VI. CONCLUSION AND RECOMMENDATIONS

### A. Conclusion

This research investigated and explicated the risk management methods applied to electricity distribution system asset management in the UAE electricity markets. The key conclusions reached by the study concerning the research issue are as follows. Firstly, electricity distribution asset management in the UAE electricity markets may entail different forms of asset management.

Therefore, there can be real time, mid-term, and long-term asset management. They provide an essential role in enhancing the electricity distribution system level of efficiency. Thus, it is evident from the above finding that the first research objective was well met. In accordance with this research results, there are several risks that companies operating in this market can face. The risks identified in this study were categorized as economic, environmental, quality, reputational, vulnerability and regulatory. Therefore, the second research objective was also met. The study also concluded, different risk management methods could be applied to electricity distribution system asset management in the UAE markets. These methods are categorized as standard, simplified, and model-based risk analysis. Accordingly, the third research objective was well met as per this finding.

### B. Recommendations

The UAE companies can follow different ways if they want to improve their risk management methods applied to electricity distribution asset management by implementing the key recommendations provided in this research. Thus, it is recommended that companies operating in the UAE electricity markets should apply a holistic risk analysis in electricity distribution system asset management. Nonetheless, since this area is fairly new within this context, it will be necessary for these companies to find new ways of gaining more experience. Moreover, this paper recommends that these companies should strive to ensure that the risk management methods that they adapt to their electricity distribution asset management are structured. This measure will be useful in providing some enhancement of the electricity distribution companies in terms of their level of competence in electricity distribution asset management.

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