Identifying delay factors in electrical distribution projects at Eskom Northern Cape Operating Unit

Prepared by: Bonga Ntshangase (NTSBON010)

Supervisor: Dr Nien Tsu Tuan

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Abstract

Delays on electrical engineering projects are a phenomenon at Eskom distribution due to a wide range of causes. These project delays result in Eskom to contravene with Electricity Regulation Act 4 of 2006 in terms of providing efficient, effective and sustainable operation of electricity supply infrastructure, promoting the use of renewable energy sources and energy efficiency as well as to facilitate universal access to electricity for South African consumers (Gazette, 2006). Eskom strives to comply with the Electricity Regulation Act by initiating and implementing strengthening projects, refurbishment (reliability) projects, direct customer projects, infills projects and electrification projects (Eskom, 2014).The severe delays experienced in the delivery of electrical distribution projects have a negative impact on South African economic growth and population.

This research study adopted interactive management methodology for the identification of project delay factors in Eskom distribution projects through the use of the idea writing technique, nominal group technique, and interpretive structural modelling technique. The interactive management methodology allows a group of people collaboratively to develop a structure that defines the relationship among the system elements. Using interactive management approach, a total of one hundred and twelve project delay factors were reduced to twenty six significant project delays which formed part of interpretive structural modelling. This research study revealed the hierarchical model illustrating interrelationships between the twenty six identified project delay factors. The research study identified three root causes of delays in electrical distribution projects at Eskom Northern Cape Operating Unit, namely “poor communication”, “poor planning”, and “project scheduling not properly done”. The three identified root causes can be used as critical points for eradicating delays in electrical distribution projects at Eskom Northern Cape Operating Unit. The research study found that a total of ten out of twenty six project delay factors were unique to Eskom Northern Cape Operating Unit.

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

DoE	Department of Energy
kV	Kilovolts
NERSA	National Energy regulator of South Africa
MV	Medium Voltage
LV	Low Voltage
HV	High Voltage
PLCM	Project Life Cycle Model
IPP	Independent Power Producers
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
RSLI	Reticulation Supply Loss Index
OHSA	Occupational Health and Safety Act
RDP	Rural Development Programme
PMBOK	Project Management Book of Knowledge
CSP	Concentrated Solar Power
PM	Project Manager
IM	Interactive Management
ISM	Interpretive Structural Modelling
NGT	Nominal Group Technique
CPM	Critical Path Method
IRP	Integrated Renewable Programme
CNC	Customer Network Centre
DEA	Department of Environmental Affairs

CHAPTER 1: INTRODUCTION

1.1 Background to the Study

Eskom is a state owned utility responsible for generation, transmission and distribution of electrical power to South African industrial, agricultural, commercial and domestic consumers. Eskom owns the electricity network comprising of more than 300 000 kilometres of power lines, 27 000 kilometres of transmission grid and over 7.5 million electrification connections (Energy, 2015a). Eskom strives to fulfil its mandate in terms of providing efficient, effective and sustainable operation of electricity supply infrastructure, promoting the use of renewable energy sources and energy efficiency as well as to facilitate universal access to electricity for South African consumers (Gazette, 2006).

South African consumers are experiencing frequent loading shedding due to the imbalance between generation capacity and load demands. The power shortages are caused by the increased load demands as a result of many years of economic growth and the provision of electricity to townships and rural areas that were not connected to the national grid many years ago (Energy, 2015a). In order to address the electricity crisis, South African government has set a target 17,800MW of new electricity to be produced from renewable energy sources largely solar, and wind (Energy, 2015b). South African government has also introduced a renewable energy programme in 2011, which to date has delivered 92 independent power producers currently generating 6327MW of power to the national grid (Energy, 2015b). The renewable energy sources contribute to the diversification of energy mix and creation of green economy jobs in South Africa (Energy, 2015b).

The Department of Energy (DoE) has collaborated with Eskom and various municipalities to initiate and implement various electrical engineering projects. Eskom distribution projects are classified into five categories i.e. strengthening projects, refurbishment (reliability) projects, direct customers projects, infills projects and electrification projects (Eskom, 2014). These high priority projects still encounter severe delays which impact South African economic growth and population negatively (Energy, 2015a).

1.1.1 Implementation of Strengthening Projects

Eskom distribution is legally responsible for the distribution of electricity at all voltage levels less than and including 132 kV (Eskom, 2014). The Electricity Regulation Act 4 of 2006 alludes the distributor's responsibly in terms of upgrade and strengthening of the electrical network to support access to electricity for South African consumers (Gazette, 2006). Therefore, Eskom ensures compliance to Electricity Regulation Act by initiating and implementing projects to upgrade the capacity of existing and new substations, high voltage (HV) lines, medium voltage (MV) and low voltage (LV) distribution lines which are classified as strengthening projects (Eskom, 2014).

The rate of urbanisation is increasing the overloading of the networks which result in frequent load shedding. An increased number of households that need to be connected to the national grid requires an infrastructural upgrade in order to cater for an increased number of household connections. The network load demand has increased exponentially due to rural townships that there were not connected to the electrical network in the past (Energy, 2010b).

The strengthening projects are planned, evaluated and executed in accordance with Eskom Project Life Cycle Model (PLCM) depicted in Fig 1-1, which consist of initiation phase, definition phase, execution phase and finalization phase.

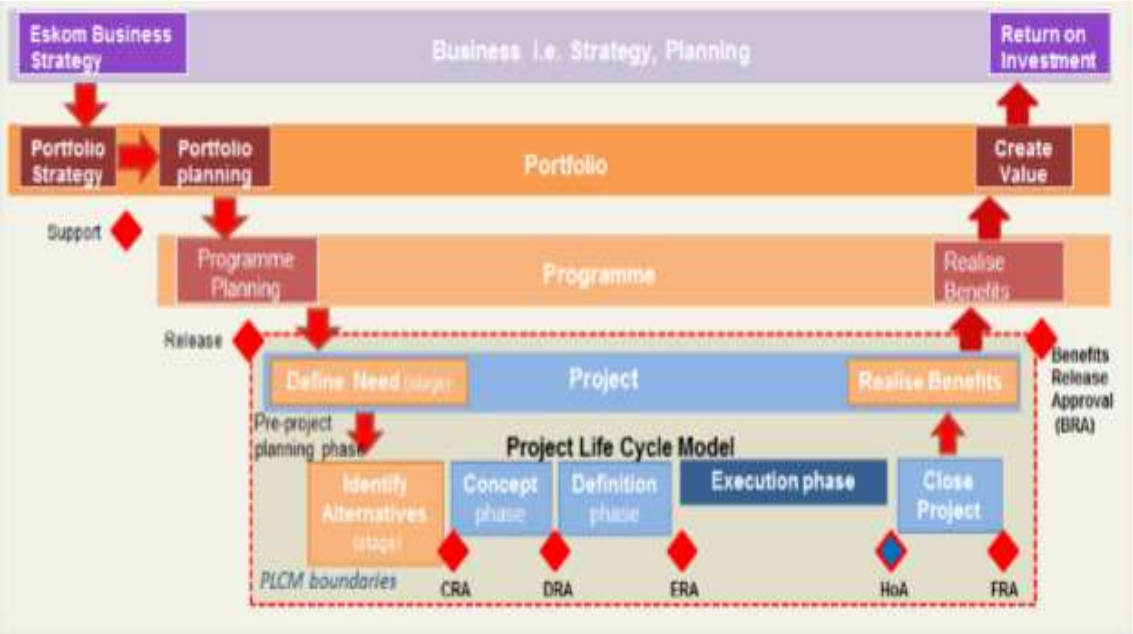

Figure 1-1: Relationship between projects, programmes and portfolios within Eskom

Eskom distribution projects are planned within a portfolio management, managed within programmes and executed within the specific PLCM (Eskom, 2015). Despite, the gate management review process for strengthening projects at Eskom distribution, construction projects are still encountering severe delays which result in the following (Eskom, 2014): -

- The Department of Energy (DoE)'s mandate to electrify consumers as part of Integrated National Electrification Programme (INEP) may not be achieved in the specific financial year (Energy, 2015c).
- The electrical network reliability requirements cannot be meet in terms of compliance to quality of supply standard (NRS 048).
- The renewable energy programme may not be realised as there is no network capacity to connect independent power producers (IPP) to the network i.e. solar, concentrated solar power (CSP), wind and hydro energy projects (Energy, 2015b).
- Communities who reside in close proximities to renewable energy plants may not benefit from social developments and employment opportunities (Energy, 2015b).
- The South African consumers may experience frequent load shedding due to inability of the network to withstand an increase load demand (Eskom, 2014) .
- The electrical equipment may be overloaded resulting in fire or explosion. This will compromise health and safety of South Africans and there will be contraventions to Occupational Health and Safety Act (OHSA), Section 85 of 1993 (Eskom, 2014).
- The network voltage dips may be experienced by the all consumers including industrial plants, which may trip out the majority of sensitive plant equipments and resulting in revenue loss on industrial consumers.
- Eskom distribution may pay penalties to the National Energy Regulator of South Africa (NERSA) for contravening the Electricity Regulation Act (Gazette, 2006).
- The existing consumers may not apply for power supply upgrade i.e. 20A to 60A for residential customers (Eskom, 2014).
- The standard to living for poor South Africans may be stagnant (Energy, 2015a).
- The voltage regulation requirement may not be met for MV and LV, which should be ± 5% and ±10% respectively (Eskom, 2014).

- The voltage unbalance on the three phase networks may exceed 2% requirement (Energy, 2015b).
- The frequency of the network may be higher than ±2.5% requirement (Eskom, 2014).
- The network performance indicators may be extremely high i.e. SAIDI, SAIFI, CAIDI and RSLI (Eskom, 2014).

The above-mentioned points illustrate very clear that the delays in construction of strengthening projects at Eskom distribution have serious repercussions on the socio-economic development and population of South Africa. The delays experienced in the delivery of strengthening projects may result in cost escalation and delays in revenue generation (Mulla and Waghmare, 2015).

1.1.2 Implementation of Refurbishment Projects

Eskom distribution has a mandate to supply South Africans with electricity that is safe, reliable and in a non-discriminatory manner (Gazette, 2006). This means that Eskom has a responsibility to monitor and maintain the electrical network to ensure provision of excellent quality of electrical supply. Many Eskom's distribution networks are in a terrible condition and falling short of the substantial investment required to maintain and rehabilitate the assets. Most distribution networks are older than 40 years and approximately 50% require immediate major refurbishment or replacement (Energy, 2015a). The distribution assets are considered old when they have reached their life span and spare parts are no longer available in the market (Energy, 2015a).

The distribution assets can be unsafe to maintain or operate due to aging over time (Eskom, 2014). The lifespan of the assets can deteriorate rapidly due to either poor or weak maintenance patterns. The National Energy regulator of South Africa (NERSA) released the findings of an audit that was done in 2011 into 11 major electrical distributors in South Africa, in 2007. Only 15% of the electrical networks were found to be at an acceptable state (Energy, 2015a). Eskom has been very slow in fast tracking in the implementation of refurbishment and maintenance projects.

Some refurbishment or maintenance projects at Eskom have been initiated appropriately, but they are still delayed during the design and implementation phases due to various reasons which may result in the following: _

- The distribution assets in the field may operate without spare parts which increases the risk of security of supply (Energy, 2015a) .
- South Africans may be exposed to risk of fire or explosion from obsolete equipments.
- There may be long hours of load shedding due to unavailability of spare parts (Energy, 2015c).
- The electrical networks may have adverse impacts on the reliability and quality of supply for customers or end users (Eskom, 2014).
- The performance indicators of the network may be extremely high (Eskom, 2014).
- There may be high rate of fatalities of Eskom operators and public members (Eskom, 2014).
- Additional consumers cannot be connected to the national grid due to capacity constraints (Eskom, 2014).
- There may be no job opportunities, skills development for local communities on projects that are dependent on refurbishment projects (Energy, 2015a).

1.1.3 Implementation of Electrification Projects

The Department of Energy (DoE) has a mandate to ensure there is universal access to electricity for all South Africans (Gazette, 2006). The electrification projects are initiated to increase access to electricity of rural households in villages or rural development plan (RDP) houses in the townships, schools and clinics in various provinces. Eskom distribution has a responsibility to plan and implement electrification projects in order to ensure that South African government's objectives are fulfilled. Eskom has experienced challenges with regard to the new infrastructure that should be built prior to connection of new households due to that the areas are extremely far from the existing electrical infrastructure (Energy, 2015c). Therefore, DoE has set targets every financial year to connect a certain of number households including shacks to the national grid (Gazette, 2006).

Eskom has connected over 5.7million households to the national grid between 1994 and 2015/2016 financial years as depicted in Table 1-1 below (Bongwe, 2013; Energy, 2015c):-

Province	Electrified Households: Eskom & Municipalities
Eastern Cape	1,023,492
Free State	363,711
Gauteng	677,133
KwaZulu Natal	935,011
Limpopo	991,602
Mpumalanga	545,809
Northern Cape	133,770
Western Cape	659,868
North West	387,576
Total	**5,732,777**

Table 1-1: Total number of electrified households between 1994 and 2016

In the period of 1994 until 2016, The total number of 65,929 households were supplied with non-grid technology using solar panels in three provinces namely KwaZulu Natal (44,266), Eastern Cape (12,282) and Limpopo (9,381) (Bongwe, 2013). Figure 1-2 below illustrates the percentage of households without access to electricity per province in both formal and informal settlements (Bongwe, 2013). KwaZulu Natal province has about 24% of population that do not have access to electricity. This graphical representation illustrates very clear that Eskom and municipalities have a lot work to do pertaining to universal access of electricity in South Africa.

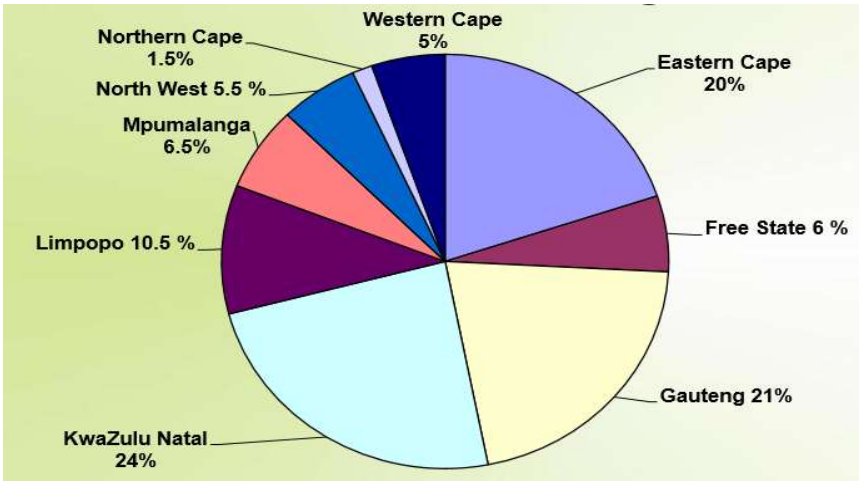

Figure 1-2: Households without electricity in South Africa (all provinces)

Eskom has lost a lot of revenue in the previously electrified areas due to electricity theft and illegal connections. The residential customers in rural areas live below the poverty lines and they don't afford to procure electricity. Eskom has made electrification projects financially viable by using spilt metering technology in order to mitigate electricity theft due to illegal connections and meter bridging (Bongwe, 2013).

Eskom has a responsibility to electrify schools to allow the use of advanced teaching aids, and clinics in order to provide optimum health care (Energy, 2010c). Eskom has a responsibility to electrify farm workers because they form an integral part of supply food chain. The living standard and socio-economic impact of the farm workers is easily improved when they have access to electricity (Energy, 2010b). Electrification projects are still completed very late at Eskom distribution which result in the following:-

- Standard of living of people in rural areas may not improve (Energy, 2015a).
- Many lives may be lost due to fires created by candles and paraffin stoves (Energy, 2015a).
- Communities may protest due to poor service delivery (Eskom, 2014).
- Communities may vandalize an existing Eskom's electrical infrastructure (Energy, 2015a).
- Communities may not create business opportunities to support their families (Energy, 2015a).
- Schools may not be able to use advanced teaching technologies (televisions, video, satellite dish, overhead projectors and computers) which enhance the quality of education (Energy, 2015a).
- Schools may not be able to serve as community centres where courses in adult basic education and skills training can be offered in the evening (Energy, 2010a).
- Former workers may not improve their lifestyle, education, and health (Energy, 2010b)
- Schools may not be hired for social activities which would generate income for them (Energy, 2010a)
- Clinics may not be able to provide optimum health care (Energy, 2010c) .
- The living conditions of staff at clinics and schools may not be improved (Energy, 2010a).

1.1.4 Implementation of Direct Customer Projects

The direct customer projects are initiated by various customers through the application process (Eskom, 2014). The customer would basically specify all power supply requirements in the application form. The industrial customers that would normally apply for power upgrades are Mines, Transnet, Sasol etc. These power upgrade projects are planned, evaluated and executed in accordance with Eskom Project Life Cycle Model (Eskom, 2015). The severe delays experienced in the delivery of direct customer projects at Eskom distribution result in the following: -

- Loss of revenue for customers due to inability to expand their operations (Energy, 2015a).
- Loss of revenue for Eskom distribution from electricity retails (Eskom, 2014).
- South Africans may lose employment opportunities (Energy, 2015a).
- Negative impact on South African economy (Energy, 2015a).

1.1.5 Implementation of Infills Projects

Infill project is an electrification of some households in an already electrified area (Energy, 2010c). These houses might have been omitted due to that the they were not there when the area was originally electrified (Energy, 2010a). These projects are handled differently using short processes. Eskom distribution is still failing to deliver these projects on time which result in the following;

- Community protests due to the number of electrified and un-electrified houses in the vicinity (Energy, 2010c).
- People may end up connecting themselves illegally to the national grid (Energy, 2015a).
- Community may be exposed to risk of electrocution especially children when they are playing in the vicinity without any knowledge of risks (Energy, 2010c).
- Eskom may lose revenue due to the number illegal connections (Energy, 2010c).
- Eskom may experience vandalism of an electrical infrastructure (Energy, 2010c; 2010a).

- Standard to living for the community members may not improve (Energy, 2010c; 2010a).

Project management tools and techniques play a significant role in the effective management of a project (Frimpong *et al.*, 2003). Therefore, good project management lie in the management tools and techniques used to manage the project. The researcher has worked for Eskom distribution, Northern Cape in Kimberley as electrical design engineer and senior electrical design engineer in the engineering and design department for approximately eight years now. The researcher has witnessed some different project categories (strengthening, refurbishment, electrification, direct customer and infills) that were not completed within time, scope and quality constraints resulting in cost escalations, loss of revenue generation, vandalism of electrical infrastructure, unreliable networks, service delivery protests, poor quality education, poor health care, poor socio-economic development and illegal connections. Therefore, there is a compelling need to conduct a study to identify the main delay factors of electrical distribution projects at Eskom Northern Cape Operating Unit, Kimberley.

1.2 Problem Statement

The problem that will be examine in this study is:

The electrical construction projects at Eskom distribution are delayed due to numerous factors, which result in unreliability of electrical infrastructure, service delivery protests, poor socio-economic development in South Africa.

1.3 Research Questions

In order to address the above-mentioned problem statement, the research questions are as follows: -

a) What are factors that cause late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit?
b) What are the key drivers or root causes of late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit?
c) What are the interrelationships between factors that cause project delays?

1.4 Research Aim

The purpose of this research study is to identify factors that cause delays in various electrical distribution projects at Eskom Northern Cape Operating Unit.

1.5 Research Objectives

The objectives of this research study are as follows:

a) To identify factors that contribute to late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit.
b) To analyse identified project delays factors and determine the key drivers or root causes of late delivery of electrical distribution projects.
c) To determine interrelationship between the identified delay factors of electrical distribution projects.
d) To determine whether the correlations or gaps exist between the identified delay factors from this research study and literature review.
e) To recommend the corrective measures that Eskom Northern Cape Operating Unit may apply in mitigating project delays on electrical distribution projects.

1.6 Structure of Research Report

The research report comprises of five chapters as follows:

Chapter one entails the background**:** to the research study in terms of background to the study, problem statement, research questions, research aim, research objectives and research methodology. It also entails definitions and categories of electrical distribution projects that are normally executed at Eskom Northern Cape Operating Unit. Chapter one discusses the repercussions that are experienced when these project categories are delayed.

Chapter two presents the literature review including the significance of project time management processes, definition of project delays and their classification, causes of delays, effect of risk management, effect of scope management and effect of procurement management on project delays. It also entails previous studies conducted by various researchers from various regions on the causes of delays. The literature reviews assisted in understating the finding of previous work done on project

delays, and finally, the comparison is made between the findings from the researchers to identify the significant delay factors.

Chapter three critically reviews the methodologies used by various researchers to conduct their surveys on the causes of delays. Chapter three discusses an application of systems thinking to problem solving and project delay factors. This chapter discusses the research design as to how will the researcher ensure that confidentiality, voluntary participations, and ethics approval will be addressed. This chapter also explains the process of interactive management methodology that will be adopted in this research study which includes idea generation, idea clarification, idea structuring, and interpretation of structured idea phases.

Chapter four presents data analysis, application of interpretive structural modelling (ISM) using Concept Star software, and the final ISM model. The research findings revealed that the primary factors that cause late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit. The research study found that 10 out of 26 project delay factors are unique to Eskom Northern Cape Operating Unit.

Chapter five presents the conclusions and recommendations of this research study. This chapter discusses a review of whether the research aim and objectives have been accomplished. This chapter presents the corrective measures that Eskom Northern Cape Operating Unit may apply in mitigating project delays on electrical distribution projects. The further studies that emanates from this research study are discussed in this chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Project Time Management

Mubarak (2015) advocates that once a project starts, certain aspects can easily deviate or go astray which can result in overspending, schedule slippage, departure from project objectives and project scope. The purpose of this section is to discuss project time management processes applied in general project management fraternity, and clarify similarities with time management processes applied at Eskom distribution Northern Cape Operating Unit. Project time management involves the processes of planning, developing, managing, executing, and controlling the project schedule (PMBOK, 2013). Mubarak (2015) defines project scheduling as the determination of timing, and sequence of operation in the project, and their assembly to give the overall completion date. PMBOK (2013), and Mubarak (2015) outline different processes of project time management as follows: -

- **Define Work Breakdown Structure**: The processes involved in breaking down the work packages into smaller activities.
- **Determine logic relationship**: The processes involved in defining logical sequence of work to attain the greatest efficiency given all project constraints.
- **Determine Activity Resources**: The processes of identifying the type, quantity, and characteristics of the resources required to complete the activity in order to allow more accurate estimation of cost, and duration.
- **Determine Activity Durations**: The processes that provide the amount of time each activity will take to complete with estimated resource.
- **Develop Schedule**: The process of entering schedule activities, durations, resource availabilities, and logical sequencing into a scheduling tool.
- **Control Schedule**: The process of monitoring the status of project activities to update project progress, managing deviation from the plan, take corrective, and preventive actions in order to minimise project risk.

The above-mentioned project time management processes are also used at Eskom Northern Cape Operating Unit in the development of project schedules.

The work packages of Eskom distribution projects have pre-defined activities in the work breakdown structures. The Eskom discipline managers from various departments assigns resources to the proposed project. The appointed project manager invites the project team to the project scheduling meeting to estimate durations of their activities. The project team can then assist the project manager with sequencing of activities. The project manager can load the activities, resources on MS project software to develop a schedule model. Finally, the project manager can circulate the baseline project schedule to all stakeholders for their reviews.

Zwikael *et al.* (2006) advocates that there are two types of project scheduling approaches namely, non-delay (early start approach), and delay (late-start) approach. The non-delay approach utilizes a concept that any activity can start without deferring other activities whereas in delay approach, activities can be delayed without delaying the duration of the entire project (Zwikael *et al.*, 2006). Eskom project managers uses non-delay approach to decrease the risks of not completing the project on time, and to ensure that resources are fully-utilised.

Nicholas and Steyn (2012) defines critical path method (CPM) as systemic approach for allocating resources among activities to reduce project duration. CPM are beneficial in determining the expected project duration, and the probability of completing the project on time. The expected project duration can be determined by finding the longest route of one or more activities connected in sequence. Nicholas and Steyn (2012) alludes that critical activities can take longer than planned due to lack of resources, and interruptions which can result in the delay of entire project completion. The project duration can be shortened by applying more resources, but doing so increases the project cost (Nicholas and Steyn, 2012). Based on researcher's experience gained from Eskom distribution business, additional resources are frequently applied on project activities in order to meet project timelines, and deliverables.

Anbair (2003) defines schedule performance index (SPI) as a measure of schedule efficiency expressed as the ratio of earned value to planned value. SPI measures how efficiently the project team is using its time (PMBOK, 2013). An SPI value of 1.00 illustrates that the project performance is efficient, and on target (Anbair, 2003). An SPI value of greater than 1.00 illustrates excellence, and high performance which means that more work was completed than planned. (Anbair, 2003; PMBOK, 2013).

An SPI value of less than 1.00 illustrates poor, and inefficient performance which means that less work was completed than planned (Anbair, 2003; PMBOK, 2013).

The schedule performances of Eskom distribution projects are not evaluated using earned value management method. However, the schedule performances are analysed by comparing the planned activity start or finish dates against actual start or finish dates to establish variances between the schedule baseline, and actual project performance. Despite all project time management processes applied on electrical distribution projects, Eskom distribution projects are frequently prone to schedule escalation.

The literature on project time management should be considered relevant to electrical distribution projects, and the knowledge gained can be used to assess project delays experienced by electrical distribution projects at Eskom Northern Cape.

2.2 Project Delay Overview

Performance measurement in construction projects is dominated by conventional measures of time, cost and quality which are called iron triangle (Atkinson, 1999). Other researchers suggested that in addition to the measures of iron triangle, customer satisfaction, and overall satisfaction of stakeholders should also be considered in the performance evaluation criteria (Toor and Ogunlana, 2010).

Haseeb *et al.* (2011) define construction delays as to execute later than intended planned or particular period or later than the specific time that stakeholders agreed on for construction project. Haseeb *et al.* (2011) further highlights that construction delays result in loss of income and unavailability of facilities for the owner and higher cost to the contractor due to labour cost increase, longer work time, and higher fabrication costs. Namzah *et al.* (2011) defines project delays as extension of time or time overrun to complete the project. Assaf and Al-Hejji (2006) and Marzouk and El-Rasas (2014) define project delay as the time overrun either beyond completion date specified in a contract to beyond the date that the parties agreed upon for delivery of a project . Project delays yield major effect on the project delivery such as time overrun, cost overrun, disputes, arbitration, total abandonment, and litigation (Aibinu and Jagboro, 2002).

Delays on construction projects are a phenomenon in various organisations due to a wide range of causes, is normally accompanied by cost and schedule overruns (Kaliba *et al.*, 2009). If project costs or schedule exceed their planned targets, customer satisfaction would be compromised. Cost overrun refer to the increase in amount of money required to construct a project over and above the original budgeted amount (Kaliba *et al.*, 2009). Schedule delay refers to a situation where a construction project does not come to completion within the planned period (Kaliba *et al.*, 2009).

Construction delays can be classified into three types namely, excusable delays, non-excusable delays and non-concurrent delays and the excusable delays are subdivided into compensable excusable delays, non-compensable excusable delays as depicted in Figure 2-1 below (Kaliba *et al.*, 2009; Abdullah *et al.*, 2010; Fugar and Agyakwah-Baah, 2010; Sunjka and Jacob, 2013). Excusable delays as the delays beyond the contractor's control such as unforeseen events and also no fault or negligence in contractor's part (Kaliba *et al.*, 2009; Sunjka and Jacob, 2013).

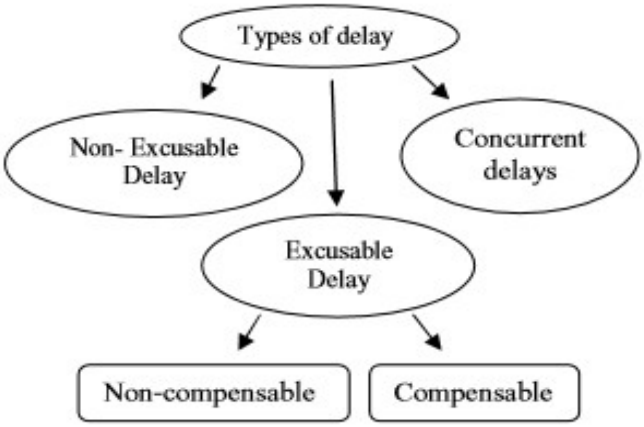

Figure 2-1: Types of delays

Sunjka and Jacob (2013) and Abdullah *et al.* (2010) define compensable excusable delays as the delays caused by the client or designer (architect or engineer) such as design errors and changes in the client's requirements. Therefore, a contractor is entitled both additional time and compensation.

Sunjka and Jacob (2013) and Abdullah *et al.* (2010) define non-compensable excusable delays as the delays that are not caused by the designer, client, contractor, supplier, subcontractor or any other party. Therefore, a contractor is entitled to extension of time only. The few examples of non-compensable delays are differing site conditions, adverse weather, acts of God, unavoidable calamities, and unusual delays in transportation (Abdullah *et al.*, 2010).

Sunjka and Jacob (2013) and Abdullah *et al.* (2010) define non-excusable delays as the delays due to contractor's weaknesses or not caused by the contractor but should be anticipated by the contractor under normal condition. Namzah *et al.* (2011) define non-excusable delay as the delay caused the contractor or its suppliers through no fault by the owner. Non-excusable delay provides no bases for recovery of either the time or the monetary impact of the delay. The contractor is the sole responsible party and consequently, they are not entitled to either extension of time or compensation (Namzah *et al.*, 2011). However, the client could be entitled to claim liquidated damages from the contractor. The cause of delay such as late in material procurement, financial difficulties faced by contractors, ineffective planning and scheduling, change management and problems with subcontractors are a few examples of non-excusable delay (Abdullah *et al.*, 2010).

Sunjka and Jacob (2013) and Abdullah *et al.* (2010) define concurrent delays as the delays due to the combination of two or more independent causes of delay during the same period. Most of the time, this delay involves excusable and non-excusable delay. Therefore, this delay may lead to disputes between contractor and client. The contractor only entitled to extension of time or compensation for the excusable delay but the penalty or liquidated damages for the non-excusable delay (Abdullah *et al.*, 2010). Construction delays have a devastating effect on contractors, clients, and consultants in terms of growth in adversarial relationships, mistrust, litigation, arbitration, cash-flow problems and the general trepidation of one another (Kaliba *et al.*, 2009). In addition to this, the project team members and key personnel usually leave the project after completion, but many projects do not conduct post-project appraisals and for those projects, it becomes impossible to learn about project process, management of life cycle and lessons learnt (Ahsan and Gunawan, 2010).

Project delays are not predictable, but each delay contains certain risk factors, and depending on the importance of activity being delayed, and amount of risk involved, delay factors can be prioritized (Yates and Eskander, 2002). Some authors have investigated types of delays encountered during the construction phase of the projects, and developed a computerized program that can be used to predict delays and provide recommendations how to mitigate delays (Yates and Eskander, 2002).

2.3 Causes of Project Delays

This section entails previous studies conducted by various authors from various regions on the causes of delays. There is a compelling need to review the delay factors identified by various authors including the methodologies used for data collection. The causes of delays identified by various authors will be summarized in order to determine the total frequencies for analysis purposes. Ntoyanto (2016) conducted a study to identify factors that influence untimely delivery of plant system modification projects which at times affect the timely delivery of outage projects at Eskom Koeberg nuclear power station in South Africa. Ntoyanto (2016) used interactive management research methodology to identify 92 delay factors, and reduced them to 21 delays factors which formed part of interpretive structural model. Ntoyanto (2016) found that inadequate proficiency of a project manager was the major cause of delays on modification projects at Koeberg Nuclear Power Station.

Baloyi and Bekker (2011) designed 60 questionnaires that were distributed to consultants (24), contractors (20) and clients (16) involved in the ten 2010 World Cup construction sites in South Africa, and Table 2-1 below shows ten factors found to have caused time delays during the construction of South African stadiums. Baloyi and Bekker (2011) designed the questionnaires comprising 19 potential factors causing cost overruns and 34 potential factors causing delays, ranked by respondents. Baloyi and Bekker (2011) analysed the results using relative importance index formula used by (Chan and Kumaraswamy, 1997; Aibinu and Jagboro, 2002).

Category	Causes of Delay	RII
Client	Incomplete drawings	0.66
Client	Design changes	0.63
Client	Clients' slow decision-making	0.63
Client	Late issue of instruction	0.63
Contractor	Shortage of skilled labour	0.63
Contractor	Poor planning and scheduling	0.59
Contractor	Labour disputes and strikes	0.59
Contractor	Shortage of manpower	0.58
Client	Change orders by client during construction	0.55
Client	Poor information dissemination	0.55
Client	Delay in work approval	0.55

Table 2-1: Top 10 factors which caused delays in 2010 South African Stadia construction projects

Al-Khalil and Al-Ghafly (1999) highlighted that public utility projects are susceptible to delays because these projects are heavily dependent on the use of equipment which requires repair or maintenance. Additionally, they require numerous permits from government authorities requiring a great deal of planning and co-ordination in order to avoid delays (Al-Khalil and Al-Ghafly, 1999). The majority of Eskom distribution projects get delayed due to environmental Impact Assessment (EIA) authorization, wayleaves and water use license and some of these projects are stopped during construction due to outstanding legal documentation (Eskom, 2014).

Al-Khalil and Al-Ghafly (1999) conducted a survey in Saudi Arabia on contractors, consultants and owners to determine the most important causes of delay in public utility projects , and discovered the ten most significant delays as follows:

- Financial difficulties.
- Delays in obtaining works permits
- Delays in payments
- Effect of soil conditions

- Changes in the project scope
- Shortage of manpower
- Ineffective scheduling and planning
- Delay in progress payment by the owner
- Government tendering system requirements
- Poor co-ordination by the contractor

Assaf and Al-Hejji (2006) studied the causes of delays in large construction projects in Saudi Arabia, and found that contractors considered the most significant delay factors as follows: -

- Preparation and approval of drawings.
- Slow working progress of contractors
- Payment delay by the owner and design variations.

Assaf and Al-Hejji (2006) found that consultants considered the most significant delay factors to be relationship between different subcontractor's schedule, cash problems, and slow decision making by the owner. However, the owner stipulated that the most significant delay factors were discrepancies in design documents, labour shortages, mistakes and, bureaucracy in project-owner organisation, and inadequate labour skills (Assaf and Al-Hejji, 2006). Sambasivan and Soon (2007) conducted survey in Malaysian construction industry, and the identified the ten most important causes of delays from a lists of 28 causes of delay as follows: -

- Contractors in improper planning
- Contractors poor site management
- Inadequate contractor's experience
- Indeqaute clients finance, and payments for completed work.
- Problems with subcontractors
- Shortage in Material
- Labor supply
- Equipements availability and failure
- Lack of communication between parties
- Mistakes during construction stage

Assaf and Al-Hejji (2006) used Spearman rank correlation to measure the relationship amongst different delay factors identified in the research study in Saudi Arabia. The correlation coefficient varies between +1, and -1 where +1 implies positive relationship (agreement), and -1 indicates negative relationship (disagreement). Assaf and Al-Hejji (2006) found that 72.4% was the highest value of agreement between owners, and consultants.

Frimpong *et al.* (2003) listed the following influential factors that caused delays in groundwater projects in Ghana:

- Poor technical performance due to improper planning.
- Monthly payment difficulties from agencies
- Lack of coordination is required to avoid delay, especially in public projects.
- Poor material procurement and escalation of material prices

Frimpong *et al.* (2003) designed questionnaire of 26 factors from preliminary investigations conducted in groundwater drilling projects between 1970 and 1999 in Ghana. It was organised in the form of a priority scaling (1 = very low, 2 = low, 3 = medium, = high, and 5 very high). The questionnaires were distributed to a random sample of 55 owners, 40 contractors, and 30 consultants. There were 125 in the group targeted 72 (75%) questionnaires were completed and returned of these 28 were from owners, 19 from consultants, and 25 from contractors (Frimpong *et al.*, 2003). The score of each factor was calculated by summing up the score assigned to it by respondents. The relative importance rate was computed using the following formula:

-Relative Importance Weight (RIW) = $\frac{\sum_{i=1}^{5} a_i.n_i}{\sum_{j=1}^{N} x.j}\ x\ 100$

Where: x_j = the sum of jth factor, j=the factors 1,2,3,4 ….N, N=is the total number of factors (26), a_i = constant expressing the weight given to the ith response i =1,2,3,4,5

Factors	Owners		Contractors		Consultants		Overall
	RIW	RANK	RIW	RANK	RIW	RANK	Ranks
Planning and scheduling deficiencies	4.52	3	4.17	10.5	4.60	4	8
Deficiencies in cost estimates prepared	4.29	8.5	4.13	12.5	4.14	10	10
Inadequate control procedures	3.75	18	3.78	16.5	3.62	19.5	19

Factors	Owners		Contractors		Consultants		Overall
Delays in work approval	3.67	20	3.87	15	3.62	19.5	18
Waiting for information	2.97	24.5	3.22	23	3.45	22.5	24
Mistakes during construction	3.48	21.5	2.96	24	3.50	21	22
Delays in inspection and testing of works	2.97	24.5	2.87	25	3.22	24	25
Cash flow during construction	4.44	6	4.48	6	4.48	5.5	7
Shortage of technical personnel	3.48	21.5	3.65	19.5	3.79	17	20
Frequent breakdowns of construction plant equipment's	4.02	14	3.65	19.5	3.85	16	16
Labour shortages	2.97	24.5	3.57	21	3.45	22.5	21
Monthly payment difficulties	4.44	5	4.96	1	4.88	1	1
Poor contract management	4.91	1	4.30	7	4.77	2	2
Shortage of material	4.09	13	3.78	16.5	4.08	11	15
Contractors financial difficulties	4.13	12	4.70	3.5	4.65	3	5
Low bid	3.94	16	4.13	12.5	3.96	14	14
Material Procurement	4.71	2	4.78	2	4.31	9	3
Imported Materials	3.82	17	3.74	18	3.91	15	17
Late delivery of materials	4.21	11	4.09	14	4.02	12.5	11
Escalation of material prices	4.48	4	4.57	5	4.37	7.5	6
Slow decision making	2.96	26	2.81	26	2.78	26	26
Inflation	4.36	7	4.70	3.5	4.48	5.5	4
Difficulties in obtaining material at current prices	3.98	15	4.17	10.5	4.02	12.5	13
Ground Problems	3.71	19	3.26	22	2.81	25	23
Bad Weather	4.29	8.5	4.22	9	4.37	7.5	9
Unexpected geological conditions	4.25	10	4.26	8	3.68	18	12

Table 2-2: Rank of all factors responsible for project delays and cost overruns according to contractors, owners and consultants

Table 2-2 depicts a summary of all factors causing delays and cost overruns in ground water projects in relative importance weights, ranking by groups, and overall ranking (Frimpong *et al.*, 2003). Frimpong *et al.* (2003) identified the most five important factors agreed by owners, contractors and consultants were monthly payments difficulties, poor contract management, material procurement, poor technical performance, and escalation of material. The first most important factor is failure to provide adequate

funding resources to contractors for the completed work, which makes difficult for the contractor to meet project objectives (Frimpong *et al.*, 2003).

Sunjka and Jacob (2013) conducted a study on significant causes and effects of construction project delays in the Niger Delta region in Nigeria. The questionnaire was designed on the groupings of 38 causes of delay factors and 8 effects of delays. The 38 causes of delays were categorised into client related issues, contractor related issues, labour and equipment related issues, material related issues, community related issues, contractual related issues, and external issues (Sunjka and Jacob, 2013). The outcome from mean score analyses using 3.5 as a cut-off point for significant factors and the sub-hypotheses testing illustrated that the respondents perceived 11 factors were the most important causes of project delay factors in the Niger Delta region as follows (Sunjka and Jacob, 2013):

- Late identification and resolution of drawings and specification errors and omissions by the consultants.
- Delay or non-payment of compensation to the communities.
- Selection of inappropriate consultants and contractors by the clients.
- Weather conditions.
- Lack of community buy-in.
- Poor contract management by the consultants.
- Inappropriate design by the consultants.
- Unrealistic contract duration by the clients.
- Poor coordination of sub-contractors by the contractors.
- Youth unrest, militancy, and community crises.
- Inadequate planning by the contractors.

Odeh and Battaineh (2002) conducted a survey aimed at identifying the most cause of delays in construction projects with traditional type contracts. The survey was based on 28 well recognised causes of delays in Jordan to which participants were asked to indicate their levelled of importance of each cause. These were categorised into 8 major groups which were client related factors, contractor related factors, consultant related factors, material factors, labour and equipment factor, contract factor, contractual relationships factor, and external factors (Odeh and Battaineh, 2002). The respondents were asked to express their perceptions of the relative importance of

each of 28 causes of delays as either extreme, very, moderate, slight or not important (Odeh and Battaineh, 2002). The following formula (relative importance index) was used to determine the ranking of different causes from the point of view of contractor and consultants: -

$$I = \frac{\sum_{i=1}^{5} W_i \, X_i}{\sum_{i=1}^{5} X_i}$$

where i = response category index = 1,2,3,4 and 5 for not slightly, moderately, very, and extremely important

W_i = weight if the ith response =0,1,2,3,4 respectively, and X_i = frequency of ith response given as a percentage of the total response of each cause.

Category	Factors	Contractors		Consultants	
		Index	Rank	Index	Rank
Client	Finance and payments of completed work	3.30	4	3.32	2
	Owner Interference	3.51	2	3.21	4
	Slow decision making by owners	3.24	8	3.16	5
	Unrealistic imposed contract duration	3.08	13	3.11	6
Contractor	Subcontractors	3.21	9	3.26	3
	Site management	3.29	5	2.58	13
	Construction Method	3.29	5	2.37	17
	Improper Planning	3.14	10	2.95	8
	Mistakes during construction	2.56	17	2.74	11
	Inadequate contractor experience	3.37	3	3.37	1
Consultant	Contract Management	3.10	12	3.00	7
	Preparation and approval of drawings	2.32	21	2.21	19
	Quality Assurance or control	2.06	25	2.11	21
	Time for approval of tests and inspections	2.46	18	2.47	15
Material	Quality of Material	1.75	26	2.00	23
	Shortage in Material	3.11	11	2.79	10
Labor and equipement	Labor Supply	2.63	16	2.63	12
	Labor Productivity	3.60	1	2.89	9
	Equipment availability and failure	3.25	7	2.42	16
Contract	Change orders	2.40	19	1.79	26
	Mistakes and discrepancies	3.05	14	2.05	22
Contractual relationships	Major disputes and negotiations	2.94	15	2.16	20
	Inappropriate organisational structures	2.27	22	2.26	18
	Lack of communication between parties	2.38	20	2.53	14
External Factors	Weather condition	2.19	23	1.95	24
	Regulatory changes and codes	1.70	27	1.16	28
	Unforeseen ground conditions	2.10	24	1.84	25
	Problems with neighbours	1.59	28	1.58	27

Table 2-3: Relative importance index and ranking of delay factors

The ranking of relative importance of delay factors in Table 2-3 illustrate that owners interference, inadequate contractors experience, financing and payment of completed work made the top five significant factors for both contractors and consultants (Odeh and Battaineh, 2002). Moreover, labor productivity, site management, slow decision making, construction methods, improper planning, and sub-contractors were among the top ten ranked factors for both groups (Odeh and Battaineh, 2002).

Marzouk and El-Rasas (2014) prepared a detailed questionnaire comprising 43 factors which cause project delays in Egyptian construction projects, and respondents were asked to determine the frequency of occurrence of each cause as follows: Rarely (R) = 1, Sometimes (S) = 2, Often (O) = 3, Always (A)= 4. The degree of severity of identified factors was also rated by the respondents using the following levels: Low (L) = 1, Moderate (M) = 2, High (H) = 3, Extreme (E) = 4. Importance Index (IMP.I) was then calculated and the following 10 factors illustrated in Table 2-4, were identified to be the top 10 factors causing delays in Egyptian construction projects. Frequency Index (F.I), Severity Index (S.I), and Importance Index (IMP.I) were computed using the following equations:

$$Frequency\ Index\ (FI)(\%) = \sum_{i=1}^{4} \frac{a_{if} * n_{if}}{4*N} X100$$

$$Severity\ Index\ (SI)(\%) = \sum_{i=1}^{4} \frac{a_{is} * n_{is}}{4*N} X100$$

$$Importance\ Index\ (IMP.I)(\%) = \frac{F.I*S.I}{100}$$

Where a_{if} and a_{is} are numbers of respondents who choose a certain frequency and severity degree respectively, n_{if} and n_{is} are degrees of frequency and severity respectively (1 or 2 or 3 or 4), N is total number of respondents.

Delay Group	Cause of delay	Imp. I
Owner related	Finance and payments of completed work by owner	58.54
Owner related	Variation orders, changes of scope by owner during construction	56.57
Project Related	Effects of subsurface conditions (e.g. soil, high water table, etc.)	56.47
Labour and equipment	Low productivity level of labour	55.61
Contractor Related	Ineffective planning and scheduling of project	55.36
Contractor Related	Difficulties in project financing by contractor	54.96

Owner related	Type of project bidding and award (negotiation, lowest bidder)	53.27
Material related	Shortage of construction material in market	51.24
Owner related	Late in approving design documents by the owner	50.84
Labour and equipment	Unqualified workforce	48.64

Table 2-4: Top ten factors which caused delays in Egyptian construction projects ranked according to importance index

Chan and Kumaraswamy (1997) used the relative importance index method for analysing the data collected from questionnaire survey, within various groups classified according to roles of participants involved in Hong Kong construction industry. The relative importance index (RII) was evaluated using the following equation: -

Relative importance Index = $\frac{\sum w}{A\ X\ N}$, $(0 \leq index \leq 1)$

Where w = weighting given to each factor by the respondents, and ranges from 1 to 5 , where 1 is not significant, and 5 extremely significant, A = is the highest weight, and N = is the total number of respondents.

Chan and Kumaraswamy (1997) identified the five most significant delays factors in Hong Kong's construction industry as follows:

- Poor management and site supervision
- Unforeseen ground conditions
- Slow speed of decisions making involving all project team
- Client initiated variations
- Necessary variation of works

Chan and Kumaraswamy (1997) found the variation of works to be commonest, and the principal source of time overruns identified in the sample of 111 construction projects in Hong Kong. Completing project on schedule reflects the contractor's ability to organise and control site operations, to optimally allocate resources, to manage the flow of information to and from the design team among the sub-contractors (Chan and Kumaraswamy, 1997). Okpala and Aniekwu cited by Chan and Kumaraswamy (1997) stipulated that ineffective management of site operations can be due a lack of

experience, and training at both the technical and managerial levels of manpower as well as low level of productivity.

Doloi *et al.* (2012) modelled the delay factors identify the most significant ones using linear regression model. The forward stepwise was used to formulate the regression models which can be expressed generally as

$$Y = a + b_1 X_1 + b_2 X_2 + \cdots b_m X_m \pm e$$

Where Y is the dependent variable, a is a constant and intercepts Y axis, $b_1 \, to \, b_{1m}$ are estimated regression coeffient, $X_1 \, to \, X_m$ are values of predictor, and e is an error.

Doloi *et al.* (2012) found out that slow decisions from owner, and rework due to errors had maximum impact on the delay durations in Indian construction projects as depicted in Table 2-5 below. Doloi *et al.* (2012) suggested that rework due to errors was due to the lack of appropriate quality planning, and implementation of quality control processes on site. Poor site management and supervision experienced across most Indian projects was due to lack of commitment, and adhoc approaches among the construction professionals.

Cause of delay	Linear regression coefficient
Slow decision from owner	0.368
Rework due to errors in execution	0.325
Poor Site management and supervision	0.299
Consultants or architect's reluctance for change	0.177
Poor labor productivity	0.165

Table 2-5: Top Five factors which caused delays in Indian construction projects

Mulla and Waghmare (2015) conducted surveys to identify the causes of project delays in Indian construction projects. Mulla and Waghmare (2015) found that the time and cost overruns of projects were mainly due to:

- Inaccurate estimate of time and cost.
- Faulty design.
- Land acquisition problems.
- Poor bidding.
- Irregular flow of finance.
- Delay in payment of work.
- Deficiencies in management.
- Delay in making decision by client, architect.

- Lack of coordination between different parties involved.
- Change in work scope.

Haseeb *et al.* (2011) investigated the cause delays in the Pakistan construction industry. Haseeb *et al.* (2011) organized each group of delay factors relevant to the client, consultant, contractor, and external, and rated them on a scale of 1 to 10. The significance rating for each factor was scored on a scale of 1 to 10, with 1 having a low importance and 10 the uppermost importance. Table 2-6 illustrates the 10 most important delay factors out of 37 delay factors which were included on the survey questionnaire of the research conducted by (Haseeb *et al.*, 2011).

Category	Causes of Delay	Critical Index
Client	Financial ability or economic arrangement for the project	4
Client	Not properly time decision	4
Client	Priority of time construction	4
Client	Not definite about material	4
Client	Late payment of bills	4
Consultants	Completeness and timelines of project knowledge	4
Consultants	Preceding working relationships	4
Consultants	Missing some feature in drawings	4
Contractor	Lack of acquiring new equipment	4
External	Changes to government regulations and laws	4
External	Weather Conditions	4

Table 2-6: Top 10 factors which caused delays in Pakistan construction projects

Ahsan and Gunawan (2010) studied 100 projects that were sponsored by Asian Development Bank, hosted by China, India, Thailand and Bangladesh. The studied projects were completed between 1986 and 2007, and were from different areas of development such as agriculture, infrastructure (road construction, electricity generation, and telecommunication), public health, financial sector, social welfare, environment and education. Ahsan and Gunawan (2010) identified that the most significant causes of delay were as follows:

- Lengthy procedure for contract evaluation, and award.
- Procurement delays
- Civil works and land acquisition delays
- Consultant recruitment delay
- Natural calamities
- Government procedural delays
- Local politics and economic problems

- Project staff hiring delays
- New scope addition
- Frequent changes of project staff

Van *et al.* (2015) developed a questionnaire to assess the perceptions of the parties involved in government projects on the impact of delays in Vietnam, South East Asia. The delays factors were ranked according to the value of their mean. The factors with mean value exceeding 3.5 represented a fair high agreement of the respondents.

Van *et al.* (2015) found that the most significant causes of delay were as follows:-

- Information delays, and lack of information exchange
- Incompetent owner
- Incompetent supervision consultant
- Inadequate contractor's human resources
- Difficulties in financing project by owner
- Incompetent project management consultant
- Incompetent design consultant
- Difficulties in financing project by contractor
- Shortage of equipment by the contractor
- Lack of strictness, and binding in contract documents

Albogamy *et al.* (2012) identified 63 causes of delays in the Kingdom of Saudi Arabia, and classified the causes into four major categories such as owner/client related factors, contractor related factors, consultant related factors, and external factors. Albogamy *et al.* (2012) used an important index formula, which was used by Assaf and Al-Hejji (2006), and Marzouk and El-Rasas (2014) to rank each delay associated with construction projects in the Kingdom of Saudi Arabia. Albogamy *et al.* (2012) found that the most significant cause of delays were as follows:-

- Low performance of the lowest bidder contractor in the government tendering system
- Delays in sub-contractor's work
- Poor qualification, skills and experience of the contractor's technical staff
- Poor planning and scheduling of the project by the contractor
- Delay in progress payments by the owner

- Shortage of qualified engineers
- Delay in preparation of shop drawings
- Cash flow problems faced by the contractor
- Inadequate early planning of the project
- Non-utilization of professional construction contractual management

Al-Momani (2000) conducted a survey to identify the causes of delays on 130 public projects in Jordan which included residential, office and administration buildings, school buildings, medical centres and communication facilities. Al-Momani (2000) found that the most significant causes of delays were as follows: -

- Design changes or poor design
- Change orders (Notification of extra work)
- Adverse weather
- Site Conditions
- Late delivery of equipment and material
- Economic conditions
- Increase in quantity

Kaming et al. (1997) undertook a questionnaire survey of project managers working on high-rise construction projects in two Indonesian cities: Jakarta and Yogyakarta. The identified variables were ranked according to their perceived importance and frequencies of occurrence. Kaming et al. (1997) found that the predominant causes of delays in Indonesian projects were as follows:-

- Design Changes
- Poor labour productivity
- Inadequate planning

Fugar and Agyakwah-Baah (2010) conducted a non-structured interviews for the identification of the causes of delays in Ghana. The survey included 130 respondents made up of 39 contractors, 37 clients, and 54 consultants. The survey data consisting of the 32 causes of delay were analysed and grouped into nine major areas according to a slightly modified version of Assaf and Al-Hejji (2006) classifications: materials, manpower, equipment, financing, environment, changes, government action, contractual relationships, and scheduling and controlling techniques. Fugar and

Agyakwah-Baah (2010) found the most significant causes of delays in Ghana were as follows:

- Delays in honouring payment certificates
- Underestimation of project cost
- Underestimation of complexity of projects
- Difficulty in accessing bank credit
- Poor supervision
- Underestimation of time for completion by contractors
- Shortage of materials
- Poor professional management
- Fluctuation of prices
- Poor site management
- Construction method
- Delay in instruction from consultants
- Late delivery of materials
- Poor design
- Breakdown of requirements

Mezher and Tawil (1998) identified a total of 64 causes of delays through literature research and local interviews with owners, contractors and firms in Lebanon. These causes were categorized in 10 main groups namely materials, manpower, equipment, financing, changes, government relations, project management, site conditions, environment and contractual relationship. Mezher and Tawil (1998) found that according to owners, the most important delay factors were financing and the scheduling of subcontractors. The most important delay factors according to contractors were contractual relationships and design changes by owners. Finally, the most important delay factors according to architecture and engineering firms were project management and rated shop drawings

Kaliba *et al.* (2009) conducted a survey to identify the causes of cost escalation and schedule delays in Zambian road construction projects. The weight average of each cause of cost escalation, and schedule delays in road construction project were determined to assess their perceived significance, and computed using the following formula; -

$$WA = \left(\frac{1}{4}\right) X \frac{\sum_{i=1}^{4} F_i R_1}{\sum_{i=1}^{4} F_i} X\ 100\%$$

Where R_i is the response type, i is ranging from 1 to 4, and F_i is the frequency or total number of respondents choosing response type i.

Kaliba *et al.* (2009) found that the most significant causes of delays in Zambia were as follows: -

- Delayed payments
- Financial difficulties
- Contract modification
- Material procurement
- Design changes
- Staffing problems
- Equipment unavailability
- Poor supervision
- Construction mistakes or method
- Poor coordination

2.4 Summary of the Literature Review Related to Studies on Causes of Delays

Based on the literature review discussed in section 2.4, finance and payments of completed work by owner was identified as one of the top ten delay factor by Kaliba *et al.* (2009), Fugar and Agyakwah-Baah (2010), Albogamy *et al.* (2012),Van *et al.* (2015), Odeh and Battaineh (2002), Marzouk and El-Rasas (2014), Frimpong *et al.* (2003), Al-Khalil and Al-Ghafly (1999), Assaf and Al-Hejji (2006), Haseeb *et al.* (2011), Mulla and Waghmare (2015), and Frimpong *et al.* (2003).

Table 2-7 depicts the summary of delay factors from literature review identified by Kaliba *et al.* (2009), Fugar and Agyakwah-Baah (2010), Albogamy *et al.* (2012),Van *et al.* (2015), Odeh and Battaineh (2002), Marzouk and El-Rasas (2014), Frimpong *et al.* (2003), Al-Khalil and Al-Ghafly (1999), Assaf and Al-Hejji (2006), Haseeb *et al.* (2011), Mulla and Waghmare (2015), (Frimpong *et al.*, 2003), Sunjka and Jacob (2013), Chan and Kumaraswamy (1997), Doloi *et al.* (2012), Ahsan and Gunawan (2010), Baloyi and Bekker (2011), Kaming *et al.* (1997), and Mezher and Tawil (1998).

The mark √ indicates the cause of delay idenfied by the respective authors, and the total rows can be added to identify the total frequencies for the same cause of delay.The causes of delay, design variation or changes has a frequency of 14, which means that it was identified as the most significant delay factors by fourteen authors in various regions as depicted in Table 2-7. The causes of delays, poor site management, and improper planning by contractors has frequencies of 10 and 9 respectively, which means that they were identified as the most significant delay factors by ten authors who conducted the surveys in various region.

Some causes delay identified by various authors have been found to be unique to the projects that were surveyed. This means that cause of delay only appear once in the entire row in Table 2-7. For an example, natural disaster, incomplete drawings and civil, lack of community buy-in, quality assurance and control, and land acquisition have a frequency of 1. These causes of delay were viewed by respondents as only applicable to research studies of projects conducted in various region.

Table 2-7: Summary of delay factors from literature review identified by various authors

Authors	**Al-Khalil and Al-Ghafly**	**(Assaf and Al-Hejji, 2006)**	**Frimpong et al. (2003)**	**Sunjka and Jacob (2013)**	**Odeh and Battaineh (2002)**	**Marzouk and El-Rasas (2014)**	**Chan and Kurmasway**	**Doloi et al. (2012)**	**Mulla and Waghmare (2015)**	**Haseeb et al. (2011)**	**Ahsan and Gunawn**	**Van et al. (2015)**	**Albogamy et al. (2012)**	**Al-Momani (2000)**	**Baloyi and Bekker (2011)**	**Kaming et al. (1997)**	**Fugar and Agyakwah-Baah (2010)**	**Mezher and Tawil (1998)**	**(Kaliba et al., 2009)**	**Total frequencies**
Causes of delay																				
Mistakes during construction		√	√		√												√		√	5
Escalation of material cost			√														√			2
Contractors financial dificulties			√						√				√				√		√	5
Delays or non-payment of compensation to communities				√							√									2
Selection of inappropriate consultants and contractors				√		√			√				√							4
Weather conditions				√	√					√				√						4
Poor contract management by consultants & owners				√	√						√	√					√	√	√	7
Lack of community buy-in				√																1

Authors	Al-Khalil and Al-Ghafly	(Assaf and Al-Hejji, 2006)	Frimpong et al. (2003)	Sunjka and Jacob (2013)	Odeh and Battaineh (2002)	Marzouk and El-Rasas (2014)	Chan and Kumasway	Doloi et al. (2012)	Mulla and Waghmare (2015)	Haseeb et al. (2011)	Ahsan and Gunawan(2010)	Van et al. (2015)	Albogamy et al. (2012)	Al-Momani (2000)	Baloyi and Bekker (2011)	Kaming et al. (1997)	Fugar and Agyakwah-Baah (2010)	Mezher and Tawil (1998)	(Kaliba et al., 2009)	Total frequencies
Causes of delay																				
Unrealistic contract duration by clients				√	√															2
Slow decision making by owners					√	√	√	√	√	√		√			√					8
Quality of material					√															1
Regulatory changes and codess					√					√	√									3
Quality assurance and control					√															1
Owner Interference					√									√						2
Unforeseen conditions					√	√	√							√						4
Labour supply					√	√									√			√	√	5
Labour productitivity								√								√				2
Change of orders					√		√							√	√			√		5
Inaccurate estimates time and cost									√	√							√			3
Civil and land acquisition											√									1
Natural disasters											√									1
Shortage of qualified workforce													√		√					2
Late issue of instruction															√		√			2
Preparation and approval of drawings	√		√		√	√		√				√	√		√					8
Incomplete drawings															√					1
Payment delays by owners	√		√		√	√				√									√	6
Design variations or changes	√			√	√	√	√	√	√	√	√			√	√	√		√	√	14
Improper planning by contractors		√	√	√	√	√							√		√	√	√			9
Poor site management		√	√	√	√		√	√	√			√						√	√	10
Inadequate contractor experience		√			√							√	√							4
Inadequate clients finance and late payment		√			√	√			√			√	√				√	√		8
Shortage of Material		√	√		√	√				√		√					√	√	√	9
Equipement availablity and failure		√	√		√					√				√			√		√	7
Poor communication between parties		√			√				√			√			√				√	6

Table 2-7: Summary of delay factors from literature review identified by various author

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Critical review of approaches employed on project delay literatures

This section critically reviews the methodologies used by various authors to conduct their surveys on the causes of delays. The majority of authors as discussed in section 2.3 used field surveys to collect data for their research studies. Survey research is a research method involving the use of standardized questionnaires or interview to collect data about people, their preferences, thoughts, behaviour in a systematic manner (Bhattacherjee, 2012). Field surveys are non-experimental designs that do not manipulate or control independent variables, but measure these variables, and test their effect using statistical methods (Bhattacherjee, 2012). Field surveys capture snapshots of practices, beliefs, or situations from a random sample of subjects in field setting through a survey questionnaires or through a structured interview (Bhattacherjee, 2012).

Bhattacherjee (2012) alludes that the researcher should carefully choose the target population from which they wish collect data, and a sampling strategy to select a sample from that population. Sampling is the statistical process of selecting a subset (sample) of a population of interest for purposes of making observations and statistical inferences about that population (Bhattacherjee, 2012). Bhattacherjee (2012) further alludes that the chosen sample should be representative of the population so that inferences derived from the sample can be generalized back to the population of interest. Sambasivan and Soon (2007) used convenience and snow balling sampling method to identify sample elements through friends, and referral networks. This sampling method was chosen to obtain large number of completed questionnaires quickly, and economical through the distribution of questionnaires from the identified friends to their friends (Sambasivan and Soon, 2007).

Fugar and Agyakwah-Baah (2010) collected research data by using two methods, firstly by non-structured interviews of 15 key role players involved in the implementation process selected from non-probabilistic snow ball technique, and secondly by questionnaires incorporating 32 causes of identified, and data collection. Fugar and Agyakwah-Baah (2010) suggests that the purpose of interviewing key stakeholders was to validate a set of pre-liminary construction delay causes gathered

from the literature review, and to determine other causes of delays in construction projects in Ghana based on key stakeholder's experience. Mezher and Tawil (1998) identified 64 causes of delays in Lebanon through literature review, and interviews. Mezher and Tawil (1998) developed questionnaires, and distributed them to owners, contractors, architectural and engineering firms. The purpose of questionnaires was to assess the relative importance of each cause of delay based on the respondent's opinion. The questionnaires were personally distributed to the respondents, and an interviewer was available to respond to any questions (Mezher and Tawil, 1998). An interview is a method of acquiring data in which qualitative or quantitative questions asked (Noonan, 2013). The interviews can be classified into structured, unstructured, and semi-structured, and their strengths and weaknesses are illustrated in Table 3-1 below (Noonan, 2013):

Structured Interview	**Un-Structured Interview**	**Semi Structured Interview**
Each interviewee is asked similar questions utilising the same order, and same wording, in same order as other participants.	Initiated by an open-ended question pertaining the area of study, with follow-up question dependent on interviewee's response.	Interview guide is designed to acquire similar types of data from all respondents.
It is easier to code, and analyse, and compare data	The researcher does not utilise an interview guide, consisting of themes rather than precise questions.	The interview offers flexibility, with open-ended questions and the increases the probability of exploring issues that may arise spontaneously.
The researcher controls the topic, and format of the interview	Processing of data acquisition can be problematic, and profligate time due to consolidation of similar statements or opinions various respondents.	The researcher can establish new ideas emerging during a session which may have not been initially considered.
It limits researcher's subjectivity	Researcher should posses good listening skills, and facilitation skills.	Researcher is able to phrase questions automatically and come up with a communication style during the session

It is efficient with regards to time.	Respondents may talk about irrelevant issues making difficult analyse the data, and code data since there is not restriction on the questions that can be asked about a topic.	Inexperienced researchers may not fail to identify where to probe responses, and ask prompt questions, therefore some relevant data may not be collected during the session.

Table 3-1: Strengths, and weakness for structured, unstructured, and semi-structured interview.

Kaliba *et al.* (2009) used structured interview questions to collect data in identifying the causes of schedule delays cost, and cost escalation in road construction projects in Zambia. The structure of interview questionnaires was based on the information gathered on literature review, and intended to identify challenges that financers, consultants, implementing agencies, and contractors experience in implementing road construction projects in Zambia. Grifee (2005) cited by Noonan (2013) suggested that interviews are the most commonly utilised method of collecting data in qualitative research because talking is natural. Noonan (2013) highlighted the following pros and cons of interview as a method of collecting data.

Pros of interviews

- Useful to attain deeper understanding and context.
- Assist participants to voice their opinions.
- Useful in generating stories, and quotes.
- Enable the researcher to develop an understanding.
- Afford the researcher a chance to listen, and observe.
- Allow more complicated questions to be asked.
- The researcher can describe the purpose of the research and respond any questions that respondents may have pertaining to the study.
- The researcher may ask questions, probe the respondent's response and new ideas that were not considered initially.
- Respondent's questions can be clarified spontaneously.
- Assist the respondents to give detailed answers.
- Can establish respondent's reasons for acting in a certain way.
- More suitable for certain individuals with reading, and writing difficulties.
- Can be fruitful for respondents as they stimulate discovery and self-exploration.

- One can tell his or he story which is personal benefit.

Cons of interviews

- May seem offensive to the respondents.
- Profligates time in arranging, travelling to the venue, and conducting the session, as well as post-interview transcription and data analysis.
- Can be costly in comparison to other data collection methods.
- Interviews on a personal matter can initiate strong feelings which must be dealt with meticulously.
- Can be vulnerable to biasness which may include:
    - ✓ The interviewee can please the researcher by given incorrect responses by saying what researcher wishes to hear.
    - ✓ Interviewee can give an official point of view rather than their personal view.
    - ✓ The desire to create a good impression may lead to participants not answering honestly.
    - ✓ The interviewees have a notion to answer something rather than to keep quite if the question cannot be answered.
    - ✓ The researcher's opinion can influence the interviewee's responses by expressing disapproval and surprise.

Based on the literature review discussed Section 2.3, Baloyi and Bekker (2011), Al-Khalil and Al-Ghafly (1999), Odeh and Battaineh (2002); Sunjka and Jacob (2013); Marzouk and El-Rasas (2014); Assaf and Al-Hejji (2006); Doloi *et al.* (2012); Fugar and Agyakwah-Baah (2010); Haseeb *et al.* (2011); Ahsan and Gunawan (2010); Van *et al.* (2015); Kaming *et al.* (1997), Chan and Kumaraswamy (1997); and Frimpong *et al.* (2003) used questionnaires to conduct their research studies in various regions. These authors collected data for their research studies from the target population mainly contractors, consultants, and clients.

Mezher and Tawil (1998) identified 64 causes of delays in two stages, firstly through literature review, and interviews in Lebanon, secondly questionnaires were developed, and distributed to owners, contractors, architectural and engineering firms. The purpose of the questionnaires was to assess the relative importance of each cause of delay, and opinions of respondents on the relative importance of each cause delay.

Frimpong *et al.* (2003) carefully designed a questionnaire of 26 factors from previous investigations conducted in ground water drilling projects between 1970 and 1999 in Ghana, which were distributed to a random sample of 55 clients, 40 contractors, and 30 consultants. Kaming et al. (1997) undertook a questionnaire survey of project managers working on high-rise construction projects in two Indonesian cities: Jakarta and Yogyakarta. Sambasivan and Soon (2007) used questionnaires to asked individuals to indicate their response category on 28 well-recognised construction delay factors by Odeh and Battaineh (2002). The respondents were asked to highlight their recommendations to improve performance of Malaysian construction industry through an open-ended questionnaire. Mezher and Tawil (1998) developed 220 questionnaires, and mailed them to the respondents involved in Construction industry. Bhattacherjee (2012) suggested that mail surveys tend to offer low response rates, and people tend to ignore them. The 220 questionnaires of the study conducted by Mezher and Tawil (1998) yielded 75% response rate which means that 165 out 220 responses were received. Bhattacherjee (2012) mentioned the researcher conducting mail surveys should continuously monitor responses as they are returned, track, and send reminders to non-respondents. This indicates very clear that response rate for mail surveys is dependent on researcher's capability to monitor and managing data collection process.

A questionnaire is research instrument comprising of a set of questions (items) intended to capture responses from respondents in a standardized manner (Bhattacherjee, 2012). Clifford *et al.* (2010) suggested that responses to survey questions are as important as the questions themselves. The questionnaires must be designed in such a way that respondents are able to read, understand, and respond to them (Bhattacherjee, 2012). Bhattacherjee (2012) suggested that questions in a questionnaire can be unstructured or structured. Unstructured questions is when a respondents are asked to provide their own words, whereas structured questions is when the respondents asked to select an answer from a given set of choices (Bhattacherjee, 2012).Clifford *et al.* (2010), and McGuirk and O'Neill (2016) suggested the following pros and cons for unstructured, and structured questionnaires.

Pros of unstructured questionnaires

- Participants are not restricted in responding questions.

- Participants factual viewpoints may be represented better.
- Participants can express their preferences, attitudes, and emotions.
- Participants can be permitted to ask the structure of questionnaire itself, and also demonstrate an alternative understanding.
- Participants can demonstrate experiences, opinions, and understandings in their own style.
- Opportunity to collect more data is provided.

Cons of unstructured questionnaires

- Questions can be difficult for participants to answer and time-wasting to code.
- Questions may result in difficulties to interpret, and analyse data.
- Questions can be omitted by the participant.
- Requires higher level of education from the participants than multiple choice.
- Answers provided by the participants may off the point resulting in poor data value.
- Questions may be unclear to participant resulting in confusion
- Extremely complicated to compare participant's responses.

Pros of structured questionnaires

- Responses can be analyzed, and coded easily which is beneficial when dealing a large number of questionnaires.
- It is easier for participants to answer questions, and fixed alternatives can guide participants in answering questions.
- Responses can be easily interpreted as they are classified into a limited set of categories.

Cons of structured questionnaires

- Closed questions are effort intensive to design, and researchers needs to have clear understanding of possible answers to the questions.
- Responses don't have personal viewpoints, and richness that can be attained from open-ended questions.
- Participant's responses are restricted to range of categories designed by the researcher.

Flood (2010) alludes that reductionism generates understanding of phenomena by breaking them down into smaller parts, and studying simple elements in terms of cause, and effect. The literature studies conducted by various authors on project delay factors reduced the large numbers identified of factors into significant project delay factors. This approach is analytical thinking where system components are broken into smaller parts for better understand ability without taking cognisance of the whole system (Nicholas and Steyn, 2012). In systems thinking, the smaller parts are analysed, relationship amongst those parts is also understood, and how parts affect the whole (Flood, 2010).

Flood (2010) suggested that there are two fundamentals of systems thinking, namely emergence, and interrelatedness. The authors of the causes of delays identified in the literature conducted their research studies perfectly in terms of ranking the importance of each delays, and categorising of delay factors into grouping, analysing the research results using software packages, and preparing conceptual models. The authors discussed in literature review failed to demonstrate interdependency, and interrelationship between the identified causes of delay factors. Although, Assaf and Al-Hejji (2006) used Spearman rank correlation to illustrate the relationship or agreement between each of the two groups of parties in the ranking of importance cause of delays.

3.2 Application of Systems Thinking to Problem Solving

Emery (1983) cited by Flood (2010) alluded that System thinking was introduced when research into living organism experienced limitations to principles of reductionism. Reductionism consist of a belief that everything in the world can be reduced, decomposed, or dissembled into smaller parts to better understand them (Flood, 2010). In system thinking, the full understanding of comes from building up the whole pictures, not only to break things into smaller components (Flood, 2010). Systems thinking is about looking at parts, and attempt to understand the interrelationship between them, but reverting back to view the whole system (Nicholas and Steyn, 2012). System thinking is characterised by emergence and interrelatedness (Flood, 2010). Ackoff (1973) suggest that in mechanism, all phenomena are explainable by using one simple relationship, cause-effect. This means that a cause is taken to be sufficient for its effect, and nothing is required to explain the effect other than its cause.

Ackoff (1973) defines system a set of interrelated elements which possesses the following characteristics:

- The part's properties or behaviour can affect the whole system.
- The part's properties and the way they affect whole system is dependent on the behaviour and properties of at least one other part in the set.
- Each element has an effect and none has an independent effect on the whole system.

Jackson (2003) suggested that Hard System Thinking (HST) is to bring together various system ideas in an organised way, and employ them to improve the problem situation. (Jackson, 2003). The applied system thinking was introduced to overcome weaknesses of hard systems thinking (Jackson, 2003).The advantages, and disadvantages of hard systems approach are illustrated in Table 3-2 below (Jackson, 2003).

Advantages of Hard System Thinking	**Disadvantages of Hard System Thinking**
It simplifies problem situating through modelling.	Require an objective account of the system of concern so that a mathematical model can be produced and an optimal solution to the problem recommended
It privileges the values and interests of its clients and customers, and lends its apparent expertise to their realization	Thinking tends to leave the human aspect of systems aside. People are treated as components to be engineered, not as actors
	It thus gives the facade of objectivity to changes that help to secure the status quo.
	Unable to handle significant complexity, to cope with a plurality of different beliefs and values, and to deal with issues of politics and power.
	Unable to deal with satisfactorily with multiple perceptions of reality

Table 3-2: Advantages and Disadvantages of Hard Systems Thinking

Jackson (1991) cited by Flood (2010) suggested that soft systems thinking is a form of systemic thinking that understands the reality as the construction of human being. Soft system generates, and works with an evolving appreciating of people's point of view (Flood, 2010). In soft systems, the full understanding of any action concept requires participation of all stakeholders including all involved in taking action as well as people affected by those actions (Flood, 2010).

3.3 Systems Thinking Applied to Project Delay Factors

This research proposes a systemic approach in identifying the delay factors in Eskom distribution projects namely strengthening, direct customer, refurbishment, infills and electrification projects. Flood (2010) suggested that in systems thinking, the phenomena are understood be emergent property of interrelated whole. This research proposes that the causes of delays will be analysed, relationship amongst the causes of delays factors will be understood, and how they affect the whole (Flood, 2010). Ackoff (1973) suggested that in mechanism, all phenomena are explainable by using one simple relationship, cause-effect. This means that the thing or event is taken to be the cause of another, and a cause is taken to be sufficient to explain the effect (Ackoff, 1973).This research proposes analysis of interrelatedness and emergence of delay factors in Eskom distribution projects, and identify the significant factors causing projects not to be executed within schedule limitations.

In soft systems approach, the full understanding of any action concept requires participation of all stakeholders including all involved in taking action as well as people affected by those actions (Flood, 2010). The researcher will engage Eskom stakeholders who are involved with electrical distribution projects to gain more understanding of the causes of delay factors. This research proposes a soft systems approach called Interactive Management methodology. The identified factors will be investigated how they influence one another through the assessments of interrelatedness.

3.4 Research Design

Research design is the process of creating activities in order to satisfactorily answer the research questions which includes choosing a research method, and formulating an appropriate sampling strategy (Bhattacherjee, 2012). Bhattacherjee (2012) alludes that the researcher should decide what research method would be employed for collecting data to address research question of interest. Bhattacherjee (2012) further alludes that the researcher should choose the target population appropriately where data will be collected, and a sampling strategy to select a sample from that population. Sampling is the statistical process of selecting a subset (sample) of a population of interest for purposes of making observations and statistical inferences about that population (Bhattacherjee, 2012).

Eskom distribution Northern Cape (Kimberley) will be selected to collect data pertaining to project construction delays as a study case. The case study will only focus on Eskom`s distribution construction projects, namely, strengthening, direct customer, refurbishment, infills and electrification projects. The other eight Eskom distribution operating units which include Gauteng, Eastern Cape, Western Cape, Mpumalanga, KwaZulu Natal, Limpopo, North West, and Free State provinces will be excluded from the research study. The interactive management methodology will be adopted by the researcher in the study project delays factors in Eskom distribution projects. The interactive management approach will be used to solve complexities of delays in Eskom distribution projects, and to determine interdependency, and interrelatedness of the project delays.

3.5 Research Ethics

Bhattacherjee (2012) defines ethics as a moral distinction between right and wrong, and what is unethical may not necessarily be illegal. Bhattacherjee (2012) postulates that researcher should not manipulate their data collection, analysis, and interpretation process in a manner that contravenes the principles of science or scientific method or advances their personal agenda. The researcher will take cognisance of ethical standards in the research survey as follows (Bhattacherjee, 2012):

- **Voluntary Participation and Harmlessness**: The research questionnaire will be designed in such a way that all Eskom sample participants will be provided

with information about the purpose of the study, who the researcher is, who will benefit from the result and what participation will be required. The Eskom participants will receive the consent form that clearly describes their right not to participate, and right to withdraw before their response in the research study (Bhattacherjee, 2012). The consent form can be found in Appendix 3.

- **Anonymity and Confidentially:** The research questionnaire is designed in such a way that it does not identify any given response with a specific respondent. This implies that names, surname, and identification numbers are not requested from Eskom participants. There will be a face to face group discussion as part of Interactive Management methodology, therefore anonymity will not be possible. The researcher will not disclose Eskom participant's response to the public forum or papers (Bhattacherjee, 2012).
- **Research Ethics Approval:** This research involves human participation, therefore UCT research committee should ensure that the principles of voluntary participation, harmlessness, anonymity, confidentiality, and so forth are preserved, and that the risks posed to humanity is minimal (Bhattacherjee, 2012). The researcher will complete the application form for ethics in research projects, and submit to the Faculty of Engineering and Built Environment for approval. The research questionnaires, and research proposal will be submitted to the Faculty Engineering and Built Environment as well. The General Manager of Eskom Distribution, Mr Klaas Gouws has granted a permission for the researcher to conduct the research survey at Eskom Northern Cape Operating Unit as illustrated in Appendix 3.

3.6 Stakeholder Identification

Complex situations can be solved utilising interactive management methodology which requires a group of people who are knowledgeable and work collaboratively in developing a thorough understanding of the situation. Therefore, the identification, and analysis of stakeholders to be involved in the IM process is extremely important. Freeman (1989) cited by Vos and Achterkamp (2006) defines stakeholder as any group or individual who can affect or is affected by the achievement of the organization's objective. PMBOK (2013) defines stakeholder as an individual, group, or organization who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project.

Mitchell cited by Achterkamp and Vos (2007) alludes that managers give high priority to a stakeholder if they believe that the stakeholder possesses legitimate claims and has powers to influence organisation's activities. The stakeholder who is believed to possess three attributes namely urgency, power and legitimacy is called a definitive stakeholder (Achterkamp and Vos, 2007). Achterkamp and Vos (2007) advocates that identifying stakeholders can be considered as drawing a line between the parties to be involved and the parties not to be involved. Ulrich (1983) cited by Vos and Achterkamp (2006) acknowledges two reasons anyone can claim belonging to a system, that is to say being a stakeholder. The first reason is that they have some kind of resource (expertise, political or financial, etc.) to contribute to the system (Vos and Achterkamp, 2006). The second reason is that they are actually or potentially affected by the outcome of the system (Vos and Achterkamp, 2006).

The stakeholders are categorised into two namely actively involved and passive involved. The actively involved stakeholders are those who actively contribute to the outcome of the projects whereas passively involved are those who are affected by the outcome of the project (Vos and Achterkamp, 2006). Ulrich cited by Achterkamp and Vos (2007) distinguished the actively involved stakeholders in terms of the clients (whose purposes are being served), the decision makers (who has the power to decide), and the designers (who contributes necessary expertise).Table 3-3 below depicts the roles, and definitions of stakeholder involvement (Achterkamp and Vos, 2007).

Role	**Definitions**
Actively involved	Actively involved stakeholder can affect the achievement of project objectives.
Client	Client is a party whose purpose is being served through the project.
Decision Maker	The decision maker sets the requirements regarding project processes, outcomes, and evaluates whether these requirements are met.
Designer	Designer contributes expertise within the project, and is responsible for the deliverables.
Passively involved	Passively involved stakeholder is affected by the outcome or project process without being able to influence the process or outcome.

Table 3-3: Roles, and definitions of stakeholders (Achterkamp and Vos, 2007).

Warfield and Cardenas (2002) suggests that the IM group workshop can comprise of 6 to 12 participants who are knowledgeable about the issue or situation. Tuan (2004) suggested that group collaborations, and co-joining various angles promote versatile solutions that can generate larger varieties. Tuan (2004) alluded that a group of people's varieties are greater than an individual's due to that each person captures a portion of a complex situation. Therefore, the research participants will be selected meticulously to ensure that they contribute positively in identifying the causes of delays in electrical distribution projects at Eskom Northern Cape Operating Unit. The roles of stakeholder involvement on delay factors of electrical distribution projects are discussed below.

3.6.1 Actively Involved Stakeholders of Electrical Distribution Projects

The network planners are responsible for producing a master network development plan comprising of long term (20 years), medium term (10 years), short term (less than 5 years) projects to address strengthening issues of the networks. The simulation studies of Northern Cape electrical distribution network are conducted by network planners utilising various modelling software's such as Dig-silent, Geo-based load forecasting, Small world, and Retic Master.

The lists of portfolios, and programmes from the master network development plans are prioritized, and allocate funding for execution according to business needs, and strategies. The selected portfolios, and programmes to be executed in the specific financial year are confirmed, and approved by the business portfolio committee. These projects are loaded on the systems using concept release approval (CRA) forms, and submitted to the investment committee for approval. These projects are managed as portfolios, and programmes through the project life cycle model.

The stakeholders from Plant Management, Operations and Maintenance, Network Planning, Electrification Planning, Business Improvement Performance Management, Material Management, Capital Accounting, and Customers Services departments can influence the processes or achievements of electrical distribution projects.

The Plant Management department is responsible for monitoring the performance of the electrical distribution networks using the key performance indicators such as system average interruption duration index (SAIDI), system average interruption

frequency index (SAIFI), customer average interruption duration index (CAIDI), and reticulation system loss index (RSLI). The Plant management department is measured on the distribution score card in terms of how many hours, and frequencies of outages is experienced by the electrical network against the targets. The long hours of power supply restoration can be caused by unavailability of spare parts, obsolete equipments on site etc. The Plant management Department is also responsible for ensuring the electrical networks meet the reliability requirements in terms of voltage unbalances (less than 2%), voltage regulation (5%, and 10%, for medium voltage, and low voltage respectively), voltage dips, flickers, and harmonics of the electrical network (Eskom, 2014). Therefore, plant managers, engineers, and technicians from Plant Management department are actively involved stakeholders and their knowledge will assist in identifying the project delay factors.

The Operation and Maintenance department is responsible for ensuring availability of equipment spares, and investments required to maintain and rehabilitate the electrical distribution assets. The distribution assets in the field may operate without spare parts which increases the risk of security of supply. The electrical equipment that operate outside the normal lifespan can result in fire, and explosion. This can compromise health and safety of South Africans resulting in contraventions to Occupational Health and Safety Act (OHSA), Section 85 of 1993 (Eskom, 2014). The appointed manager under general machinery regulation 2.1 may lose his or her government certificate of competency (GCC) as a mechanical or electrical engineer for contravening an above-mentioned act. Therefore, the managers, senior engineers, engineers, and technicians from Operation, and Maintenance department are actively involved stakeholders and their experience will assist in identifying project delay factors.

The Network Planning department is responsible for conducting studies of renewable energy programme, and advise on the availability of network capacity to connect independent power producers (IPP) to the network i.e. solar, concentrated solar power (CSP), wind and hydro energy plants. The delays in execution of strengthening projects may cause the renewable programme not to realise, which contravenes the requirements of integrated renewable programme (IRP) 2010 (Energy, 2015b). The Network planning department is also responsible for conducting network modelling to verify if there is adequate capacity to connect additional loads for electrification households. The network planners can also advise if the electrical network require any

upgrades prior to connection of the new electrification households. Therefore, the managers, senior engineers, engineers, and technicians from the Network Planning department are actively involved stakeholders and their experience will contribute in identifying the delay factors of electrical distribution projects.

The Electrification planning department is responsible for ensuring that the Department of Energy's (DoE) gazetted connections are executed appropriately in Northern Cape operating unit every financial year. The total number of electrification connections is one of the major key performance indicators of the Eskom distribution scorecard. Electrification planning department is required to submit the total number of households, and shacks connected to the national grid every quarter to the DoE Head Office (Gazette, 2006).

The Electrification department planning is also responsible for stakeholder integration management between municipalities, community chiefs, and liaison officer in villages, and community members in order to reduce the numbers of protests, and vandalism of electrical infrastructure. Electrification planning engages the community members, and chiefs to make them aware of the current electrification programme, and households to be connected to the national grid in that specific year as part of rural development programme (RDP). Therefore, the managers, planners, and co-ordinators from the Electrification planning department are actively involved stakeholders and their expertise will contribute positively in identifying project delay factors.

The Business Improvement and Performance Management (BIPM) department is responsible for managing the key performance indicators of the Operating Unit. The measured key performance indicators are electrification connections, lost time injuries, fatalities, infills connections, System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), System Loss Index (SLI). The BIPM shares the performance results quarterly with all Eskom senior managers, and employees in the operating unit. The quarterly results assist in identifying the areas that requires attention to improve the overall business performance for the region. Therefore, the senior managers, and managers from BIPM department are actively involved stakeholders and their knowledge will assist in identifying the project delay factors.

The Material Management department is responsible for ordering materials for all projects, and ensure availability of stock items. The Material department is also responsible for delivering the project materials to various site. Therefore, the buyers, and despatchers, truck drivers from Materials Management department are actively involved stakeholders of electrical distribution projects.

The Capital Accounting department is responsible for managing project funding allocated in work breakdown structure (WBS) numbers. The Capital Accounting department validates if the project has adequate funds before it can be presented to the investment committee for financial approval. The Capital Accounting department also verifies if the estimated project costs are not exceeding the DoE gazetted costs especially for electrification projects. Therefore, the managers, officers from Capital Accounting department are actively involved stakeholders and their expertise will contribute positively in identifying the project delay factors.

The Customer Services department is responsible for communication interfacing between Eskom, and its distribution customers. The ordinary, and industrial customers can apply for new power supply or upgrades through customer services (Eskom, 2014). The customer may query their electricity billing accounts through customer services. The Customer services department can also liaise with customers pertaining to dates and durations of power interruptions. The electrical contractors cannot switch off the power supply to connect new infrastructure without informing the affected customers of such interruption, and the duration. Therefore, the managers, agents, and officers from Customer Services department are actively involved stakeholders of electrical distribution projects.

3.6.2 Decision Makers of Electrical Distribution Projects

The Project Execution department is responsible for ensuring that the portfolios, programmes, and projects are executed in accordance with project management processes. The project managers are appointed formally to manage projects through phases or gates such as initiation (CRA), definition (DRA), Execution (ERA), Close-out or Finalization (FRA) phases. The Project managers are responsible for ensuring that project management plans are developed for all projects which include schedule, scope, quality, risk, human resources, communication, and cost management plans.

The project managers ensure that all programmes, and projects are scheduled by integrating all resources from various departments such as Network Planning, Electrification Planning, Engineering and Design, Land development, Operations and Maintenance, Plant Management, Capital Accounting, Customer Network Centres and Customer Services Centres. The project managers ensure that all projects are approved by the technical, and investment committees. The project managers have fundamental duties of co-ordinating all resources in order to achieve the business strategies. Therefore, the portfolio managers, programme managers, project managers from the Project Execution department are decision makers of electrical distribution projects.

3.6.3 Client Stakeholders of Electrical Distribution Projects

The Customer Network Centre (CNC) department is responsible for the maintenance of the electrical distribution infrastructure, and ensuring that the power supply is restored as soon as possible after the interruptions. The CNC department is also responsible for arranging outages in order to implement electrical projects because some projects cannot be connected directly to the existing network under live conditions.

All electrical distribution projects are handed over to the CNC department after commissioning, and acceptance by all project stakeholders. The CNC can assist in connecting new electrical projects under live conditions to minimise outage frequencies (SAIFI), and outage durations (SAIDI) of the electrical network. The CNC can go out to site frequently to address network outages or faults due to poor maintenance of the network. All Eskom departments should ensure that all electrical projects are delivered within scope, schedule constraints, and meeting the CNC expectations. Therefore, the supervisors, engineers, field technicians, and artisans from the CNC department are the clients of electrical distribution projects.

3.6.4 Designer Stakeholders of Electrical Distribution Projects

The Land Development department is responsible for addressing all environmental, survey, land, and right issues required by all electrical distribution projects. Environmentalists assist in arranging environmental impact assessment (EIA), and Water Use Licence Authorization (WULA) through the Department of Water, and

Environmental affairs. The construction of projects cannot commence without these approvals, otherwise there will be contraventions to National Environmental Management Act (NEMA). The surveyors assist in identifying the High Voltage (HV), Medium Voltage (MV) and Low Voltage (LV) line routes, and positions of the support structures, and poles. The land and rights officers assist in negotiating with land owners in terms of wayleaves, and registered servitudes. Therefore, the environmentalist, surveyors, and land, and right officers from the Land Development department are the designers of electrical distribution projects.

The Network Engineering and Design (NED) department is responsible for producing the final design packages of electrical distribution projects. The NED department comprises of three sections namely primary plant design, control plant design, and reticulation design. The pre-liminary designs are presented by the engineers to the Technical Evaluation Forum (TEF) for technical approval. The approved pre-liminary designs are presented by senior design engineers to the Northern Cape Operating Unit Investment Committee (NCOUIC) for financial approval. The long lead materials can be ordered once the projects have been approved financially. The final design packages are compiled by design engineers incorporating sub design packages from Land Development, and Control Plant departments. The final design packages are verified for conformance to standards, and specifications by the senior design engineers. The final design packages are formally handed over to Project Execution department to initiate the execution phase of the projects. The senior design engineers, and engineers can provide technical support to Project Execution department during the construction phase of the projects. Therefore, the, managers, senior design engineers, engineers, and technicians from NED department are the designers of all electrical distribution projects.

3.6.5 Passively Involved Stakeholders on Electrical Distribution Projects

Communities in the Northern Cape are unable to fast track the delivery of electrical distribution projects, however they are the main beneficiaries of the electrical distribution infrastructure. The industries in the Northern Cape are unable to influence the processes involved in the delivery of electrical distribution projects. The Department of Energy (DoE) is interested in the total number of households connected to national grid at the end of each financial year as per the approved government

gazette. Warfield and Cardenas (2002) alluded that Interactive Management (IM) involve participants in a group who are knowledgeable of the situation under analysis and to elaborate on the basis for effective action. The stakeholders from the Department of Energy (DoE), Northern Cape Communities and Northern Cape Industries are not knowledgeable about the processes involved in the delivery of electrical distribution projects. Therefore, the Northern Cape communities, Northern Cape industries, and DoE are excluded from this research survey as it is only limited to Eskom Northern Cape Operating unit.

3.7 The Process of Interactive Management

Interactive Management (IM) is a system of management that can applied to solve complex problems or situations that cannot be solved easily using the normal problem solving processes (Warfield and Cardenas, 2002). The development of IM is based on the recognition that in order to cope with complex situations, there is a need for a group of people, knowledgeable of the situation, to tackle together the main aspects of concern, to develop a thorough understanding of the situation under analysis and to elaborate on the basis for effective action; all these are founded in a spirit of collaboration, commitment, and within the framework of a serious and organized effort (Warfield and Cardenas, 2002).

Tuan (2004) alludes that interactive management is a tool for solving engineering problems, and its central mechanism is interpretive structural modelling. IM permits a group of people construct a model collaboratively which displays the interrelation of system's components (Tuan, 2004). Tuan (2004) suggested that there is a need for requisite variety in a decision making system in order to cope with variety of its environment. A group of people's varieties are greater than an individual's due to that each person captures a portion of a complex situation (Tuan, 2004). Tuan (2004) suggested that group collaborations, and co-joining various angles promote versatile solutions that can generate larger varieties. Tuan (2004) further suggested that group collaboration expand the breadth and depth of human horizon spectrum, and increase in designing system's variety which is critical to solve complex situations.

The interactive management involves the following four interrelated phases (Warfield and Cardenas, 2002; Nthunya *et al.*, 2017);

- **Idea Generation Phase**: This phase involves identification of the people to produce many ideas to a state issue.
- **Idea Clarification phase:** This phase involves bringing together a selected group of participants who are knowledgeable about the issue or situation to review each generated idea.
- **Idea Structuring Phase:** This a phase where participants examine if a contextual relationship exists between two elements.
- **Interpretation of the structured idea phase:** This is a phase where the produced model is reviewed through interactive management session which facilitates learning amongst stakeholders.

In order to execute the above-mentioned phases, the following tools or techniques are utilised as part of the Interactive Management process (Warfield and Cardenas, 2002):

- **Idea Writing Technique**: generates many ideas from the group
- **Nominal Group Technique**: prioritizes, and select solutions.
- **Interpretive Structural Modelling Technique:** a pattern or structure of elements associated with issue formulation.

Interactive management (IM) methodology will be adopted in this research for the identification of project delay factors in Eskom distribution projects through the use of the idea writing technique, nominal group technique, and interpretive structural modelling technique. (Warfield and Cardenas, 2002).

3.7.1 Idea Generation Phase

The idea writing technique will be used by the researcher during an idea generation phase. Warfield and Cardenas (2002) define Idea writing technique as a process of producing various ideas to a stated issue from one or small group. The advantages of idea writing techniques are as follows (Warfield and Cardenas, 2002):-

- More ideas can be generated in a short period of time which increases the understanding of an issue.
- Participants can write out ideas concurrently.
- Individual group can share a single room.
- Encourages contributions from reticence, and quite individuals.

- Process can be easily understood by facilitators.

Each group participant is requested to silently generate ideas in response to the triggering question (Warfield and Cardenas, 2002). The triggering question that will be addressed in this research study is, what are the main factors that cause late completion of electrical projects in Eskom distribution? The researcher will design the closed-ended questionnaires to allow Eskom participants to indicate their current departments and the level in which project categories are delayed in terms of very high, high moderate and low. The closed-ended questionnaire will also be designed such that Eskom participants are able to indicate the stage gate in which project categories are delayed. The purpose of ranking project types and indicating the stage gates will be to provide additional information echoing background to the study.

The researcher will design open ended questionnaires where Eskom participants will be asked to list 6 factors subjectively that they perceive cause late completion of electrical projects at Eskom distribution. The open-ended questionnaires will assist the researcher to collect data pertaining to late completion of electrical distribution projects, namely refurbishment, strengthening, infills, direct customer, and electrification projects. These project categories are executed following the standard Eskom project life cycle model. Therefore, the researcher will group these categories, and refer to them as Eskom electrical distribution projects in order to reduce the number of questionnaires.

3.7.2 Idea Clarification Phase

The nominal group technique will be applied by the researcher to clarify delay factors during idea generation phase. Warfield and Cardenas (2002) defines nominal group technique as a process of generating ideas, clarifying ideas, doing a preliminary partitioning of the set of generated and classified ideas, based on a criterion of relative saliency, and helping to build a spirit of participation and teamwork or group morale. Once the participants have completed writing their ideas, the facilitator can conduct a round robin of ideas where participants present ideas at the same time. When all ideas have been displayed on the wall, the process continues with sequential clarification of each idea (Warfield and Cardenas, 2002). The group can review each generated elements, and eliminate duplications or unnecessary elements (Tuan, 2004).The participants can requested to select five ideas that they perceived to be

important, and rank them in the order of importance (Warfield and Cardenas, 2002). (Taun, 2004) suggested that a list of combined ranking can be produced by combining various rankings of each applicant in order to reduce session time during the modelling process.

The researcher will select Eskom participants from various departments meticulously, who are involved with electrical distribution projects in order to attain the variety of project delay factors.

3.7.3 Idea Structuring Phase

Interpretive structural modelling will be applied by the researcher to structure project delay factors identified during idea generation, and clarification stages. Malone (1975) defines Interpretive structural modelling as a methodology which aids individuals, and small groups in developing an understanding of complex situations. ISM is an advanced interactive planning methodology that allows group of people, working as a team to develop a structure that defines the relationships among element in a set (Bolanos *et al.*, 2005). ISM provides the means to formulate a pattern or structure of elements associated with issue formulation (Warfield and Cardenas, 2002). ISM can enable a group of people collaboratively to construct a model which manifest the interrelation of system's components (Tuan, 2004).

The ISM is implemented in a man and machine interpretive environment such that human users are responsible for making subjective judgements while the computer is employed for performing, and displaying the results of simple logical operations (Malone, 1975). Figure 3-1 below illustrates the functional details of ISM process (Malone, 1975).

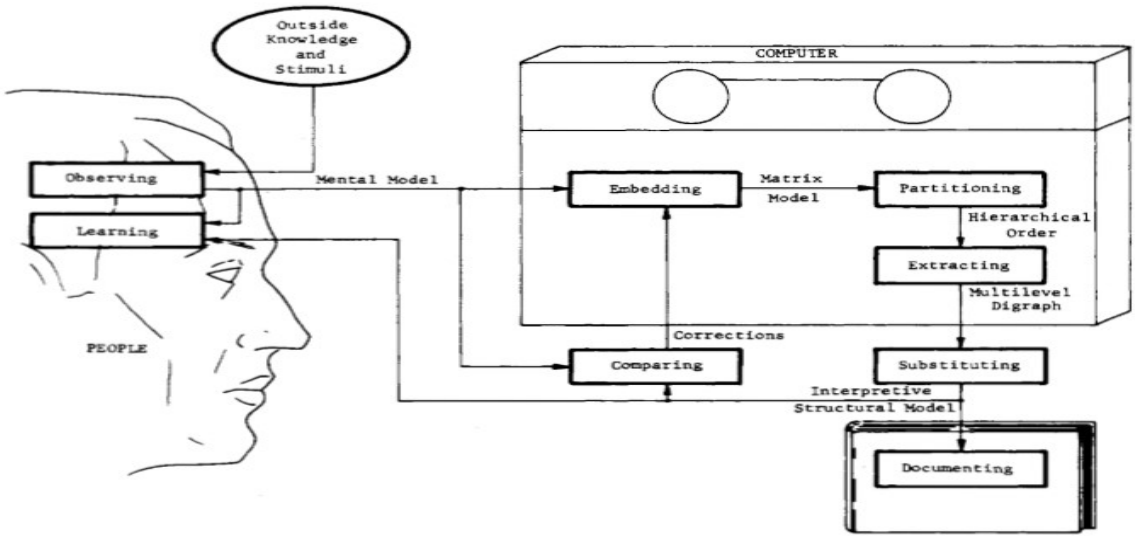

Figure 3:1: Functional representation of interpretive structural modelling process (Malone, 1975)

ISM assists to extract the group's knowledge by focusing discussion on only one pair of issues at a time (Sorach, 2014). The process of constructing an ISM creates clarity, and common understanding within the group (Sorach, 2014). The fundamental of ISM processes are element set, and a contextual relation. The element set is identified with some situational context, and contextual relation is selected as a possible statement among the elements in a manner that is contextually significant for the purpose of enquiry (Malone, 1975).

ISM uses the mathematic fundamental of Transitive Logic to reduce the number of pair-wise analysis needed to create the model, and to simplify the topology of the model (Sorach, 2014). The transitive logic states that for any three ideas **(A,B,C**) with a given relation (→) if (Sorach, 2014) :

- A has the relation to B, $(\mathbf{A} \rightarrow \mathbf{B})$
- And B has the relation to C, $(\mathbf{B} \rightarrow \mathbf{C})$
- Then A has the relation to C , $(\mathbf{A} \rightarrow \mathbf{C})$ or $(\mathbf{A} \rightarrow \mathbf{B} \rightarrow \mathbf{C})$.

ISM uses full transitive logic inferences, the No, and Yes votes imply relationships. This gives the greatest reduction in the number of votes required to construct the models (Sorach, 2014). The embedded operation makes transitive inferences within the matrix to guide to the user pertaining to the presence or absence of relation between pairs of element (Malone, 1975).

The group specifies a relational statement that defines the type of relationship desired such as aggravates, enhances etc. (Bolanos *et al.*, 2005). The computer tracks all the responses from the user which creates entries to the reachability matrix (Malone, 1975). For an example, the hierarchical depicted in Figure 3-1 below is a four element system $S = \{1,2,3,4\}$.

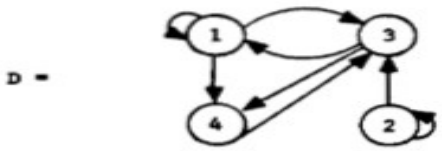

Figure 3-2: Extracted diagraph for a four element system (Malone, 1975).

The binary matrix representation for the diagraph illustrated above is as follows:

$$A = \begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ 1 & 1 & 0 & 1 & 1 \\ 2 & 0 & 1 & 1 & 0 \\ 3 & 1 & 0 & 0 & 1 \\ 4 & 0 & 0 & 1 & 0 \end{array}$$

Figure 3-3: Binary matrix for a four element system

The binary reachability matrix is constructed by setting $a_{ij} = 1$ where there is relationship from element s_i to element s_j , and by setting $a_{ij} = 0$ elsewhere (Malone, 1975). The element s_i is reachable to s_j if the path can be traced from s_i to s_j .The rearrangement, and partitioning of reachability matrix to align with to the reordering process of element set is done in the computer without any user's interference (Malone, 1975). ISM allows the user to do comparison between the mathematical operation, and heuristics, and effect the required changes (Malone, 1975). Lastly, substitution process comprises of interpretive symbols, and text required to create the final interpretive structural model which can viewed by a larger audience (Malone, 1975).

ISM will be applied in this research study to create diagraphs that will be converted into a structural model in order to make judgements pertaining to interrelationships of project delays. The researcher will use Concept Star software to construct an interpretive structural model, analyse interrelationships, and interdependencies between project delays factors in Eskom distribution projects.

3.7.4 Interpretation of Structured Idea Phase

The interpretation of structured idea is the final phase to review the produced model through interactive management session (Nthunya *et al.*, 2017). The researcher as an IM facilitator will read, and interpret the generated diagraph to all workshop participants. The researcher will permit the participants to change votes if required. The researcher will finally discuss the identified main delays factors, and interrelationships amongst them.

CHAPTER 4: RESEARCH FINDINGS AND DISCUSSION

4.1 Stakeholder Responses

The sample questionnaire depicted in appendix 4 was distributed to the stakeholders at Eskom Northern Cape Operating Unit comprising of two sections. The main purpose of the first section of the questionnaire was to identify the current stakeholder's departments, allow stakeholders to rank electrical projects, to indicate the stages where projects are delayed, and to measure the application of project time management processes. The purpose of ranking project types was to provide additional information echoing background to the study. The second section of the questionnaire is discussed in section 4.3.

4.1.1 Departments in Eskom Distribution Northern Cape

A total of 25 responses were received from the survey questionnaire. Figure 4-1 depicts the number of respondents per department who responded to the questionnaire. A higher number of respondents in the questionnaire were from Network Planning, and Network Engineering and Design departments, which were 6, and 7 respectively.

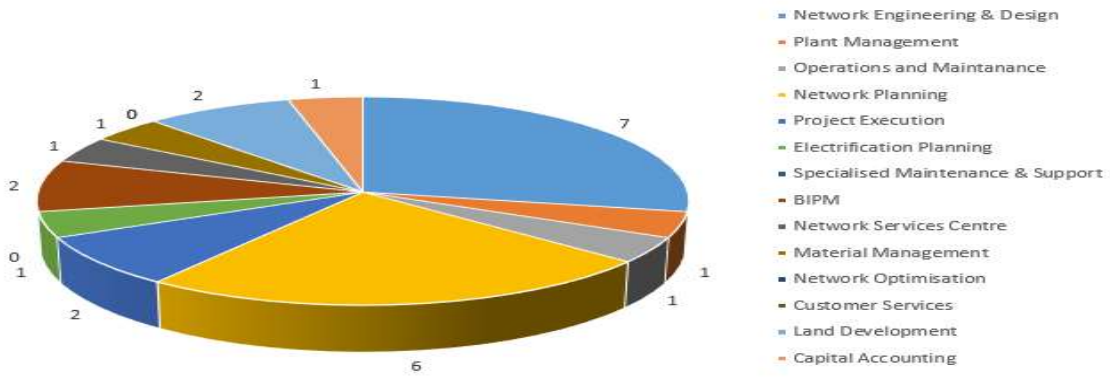

Figure 4-1: Number of respondents per department

The respondents from these departments provided valuable information pertaining to the delay factors, which will assist in addressing challenges encountered in the initiation, design, and execution of electrical distribution projects at Eskom.

4.1.2 Rankings of Electrical Distribution Projects

The main purpose of this section in the survey questionnaire was to allow the respondents to indicate the level in which electrical project categories are delayed in terms of very high, high, moderate, and low scale. The number in Table 4-2 below represents the total respondents who ranked the particular electrical project category. There were nine respondents who ranked the delay of electrification projects as high. A total of nine respondents ranked the delay of strengthening projects as high. A total of ten respondents ranked the delay of refurbishment projects as very high. A total of seven respondents ranked the delay of infills projects as moderate. Finally, a total of eleven respondents ranked the delay of direct customer projects are moderate.

As depicted in Table 4-1 below, the total number of ten respondents indicated that refurbishment projects are delayed very high, and the total number of eight respondents indicated that strengthening projects are delayed very high as well.

	Very High	High	Moderate	Low
Electrification projects	4	9	7	4
Strengthening projects	8	9	3	1
Refurbishment projects	10	8	2	0
Infills projects	5	4	7	5
Direct customer projects	4	5	11	2

Table 4-1: Rankings of electrical distribution projects

As discussed in section 1.1.1, strengthening projects are initiated and implemented to upgrade the capacity of existing and new electrical infrastructure which include substations, high voltage (HV) lines, medium voltage (MV) and low voltage (LV) distribution lines. It is important to note that when strengthening projects are delayed severely, there will be no capacity on the electrical network to connect direct customer projects, infills projects, and electrification projects. The unavailability of spare capacity on the electrical infrastructure can delay the implementation of renewable energy programme to contribute to the diversification of energy mix and creation of green economy jobs in South Africa (Energy, 2015b).

As discussed in section 1.1.2, the delay in the implementation of refurbishment projects cause the electrical distribution assets in the field to operate without spare parts which increases the unreliability of power supply system. The delays can also

increase the risk of fire or explosion due to obsolete electrical equipments. This may result in contraventions of Occupational Health and Safety Act 85 of 1993.

4.1.3 Project Life Cycle Model of Electrical Distribution Projects

As discussed in section 1.1.1, Eskom distribution projects are planned, evaluated and executed in accordance with Project Life Cycle Model (PLCM) which comprises of initiation phase (CRA), definition phase (DRA), execution phase (ERA) and finalization phase (FRA). The CRA stands for concept release approval, DRA stands for definition release approval, ERA stands for execution release approval, and FRA stands for finalization release approval. Eskom participants were requested to indicate the stage/s where electrical distribution projects experience severe delays. It is interesting to note that 17 participants indicated that distribution projects are frequently delayed in the execution phase of projects based on their experience as depicted in Figure 4-2 below. The participants indicated that projects are delayed in processes involved in approving of project funds, appointment of contractors, delivering of material, and actual construction on site.

A total 14 participants indicated that electrical distribution projects are also delayed in the definition phase. The Eskom participants also indicated that projects are delayed due to adherence of standard processes in approving the DRA stage gate, and late delivery of documentation from various departments which forms part the final design packages.

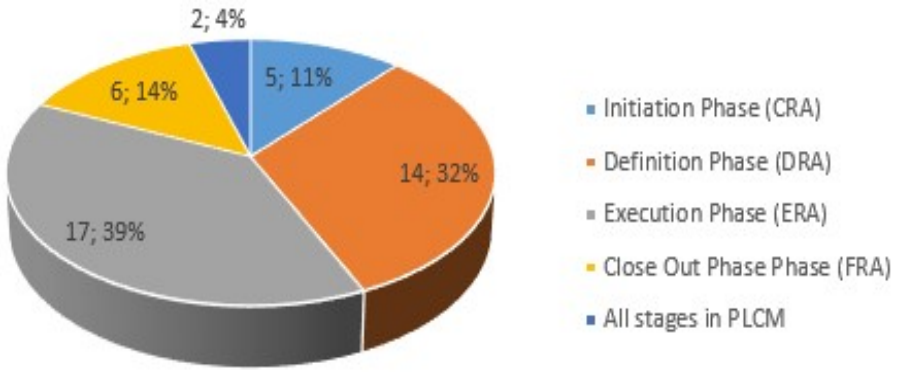

Figure 4-2: Phases of Project Life Cycle Model

4.1.4 Project Schedule Management Processes

The participants were requested to indicate whether the project scheduling processes are done appropriately at Eskom Northern Cape Operating Unit. This was done to measure the application of project time management processes. It is interesting to note that only 2 participants indicated that project scheduling is done, and the other 23 participants indicated that project scheduling is not properly done as depicted in Figure 4-3 below.

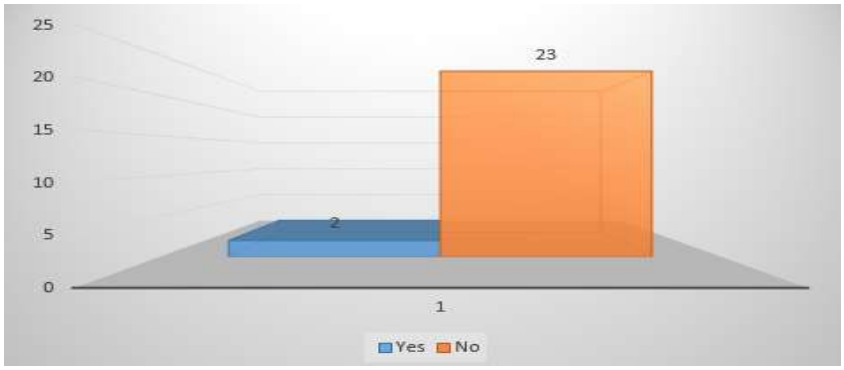

Figure 4-3: Participants response on project scheduling processes at Eskom

Eskom participants indicated that the project time management processes that are not normally done include scheduling of project deliverables, developing, and controlling the project schedule. Therefore, distribution projects can easily deviate from the objectives, and scope if project time management process are not followed at Eskom Northern Cape Operating Unit.

4.2 Idea Generation

As discussed in Section 4.1, the survey questionnaire was distributed to the participants from various departments which consisted of two sections. The main purpose of the second section was to get an understanding of the delays factors in electrical distribution projects at Eskom Northern Cape Operating Unit. In order to conduct an idea generation process, each group participant was requested to silently generate ideas in response to the triggering question (Warfield and Cardenas, 2002). Therefore, the research participants were requested to list 6 factors which in their perception result in late completion of strengthening, refurbishment, infills, direct customer, and electrification projects. The participants were also requested to give a brief description of each identified factor. The completed questionnaire can be found

in Appendix 5. Table 4-2 illustrates the 112 initially identified delay factors encountered in the initiation, definition, execution, and close-out phases of electrical distribution projects at Eskom Northern Cape Operating Unit.

Participants	Delay Factor	Description of delay factor	Stakeholder's Department	Stakeholder's role
Participant 1	Unavailability of wayleave agreements	The final design packages cannot be finalized without the wayleave agreements.	Network Engineering and Design	Designer
	Poor Planning	Many projects in the Northern Cape Operating Unit are initiated without proper investigations, and are based on wish list methodology.		
	Financial constraints	Currently many projects in Eskom are delayed due to a funding issue.		
	Incorrect project classification	The completion of self-build projects in the capital environment is delaying the projects. The minor works should be the platform to run self-built projects		
Participant 2	Unavailability of Surveyor General (SG) drawings	The design engineers for electrification are forced to pick up co-ordinates for each stand on site, which delays the detailed engineering design handover date.	Network Engineering and Design	Designer
	Human resource constraints	Currently in Network Engineering & Design which is responsible for DRA phase of a project life cycle model. There is only one draughts personnel, no Civil		

		engineer, No Senior Design Engineers for MV/LV, and HV Lines.		
	Unclear scope definition	Most of refurbishment projects are delayed on execution phase due to overlooked scope of work e.g. implementation plan they often struggle to acquire needed outages during construction which results in project delays.		
	Unavailability of material	This is very common in most electrification projects. Sourcing of material not happening in time.		
	Project scheduling not done	Project scheduling is not done appropriately, and creates confusion among project team members. The project team members focus on different priorities.		
	Project Life Cycle Model not followed	The stakeholder input meetings, project scheduling and construction handover meetings play a major delay in projects.		
	Poor planning	Inadequate information at CRA stage. No or poor customer information. Tribal issues which delay projects.		
	Community unrest	Communities have a tendency of stopping projects their households are not electrified as part of the project.		

Participant 3		Communities end-up vandalising the material for the projects, which delays the project drastically.	Plant Management	Actively Involved
	Poor communication	Eskom project managers fail to co-ordinate the stakeholders, which will cause the project to deviate from project objectives.		
	Poor contractor experience	Eskom contractors have constructed projects with a lot of defects. These projects have been found not be accordance with drawings, and specifications.		
	Adherence to policies, and standards	Projects in NCOU have to follow workflow processes. Electrification projects cannot proceed if the change control forms are not signed by the department of energy. The project cannot be presented to the investment committees for financial approval.		
	Incorrect drawings	Contractors are expected to have access to Eskom DT website to download all standards, and specifications. Contractors end up using outdated drawings due to access issues, which delays projects. Projects are delayed when the conducts re-work in order		

		to conform to the latest standards.		
	Breakage of equipment's	The drills get damaged when drilling rocks on site. This delays the construction of the project.		
Participant 4	Environmental approvals	The new substations require an environmental impact assessment (EIA) approval. The project should have Tree Cutting Permits if there are tree to be cut. If the line runs across the river, then we as Eskom we need to apply for Water Use Licence Authorization (WULA) of which it takes time to be approved.	Land Development	Designer
	Servitude and Wayleave Approvals	Refurbishment and strengthening projects are delayed because of wayleaves not signed on time. The reason is that the land owner (s) does not have any interest in the line that is running in the farm or he/she had issues with Eskom previously and those issues were not resolved. The farm owners normally refused to sign the wayleave if the original issues were not resolved. Some land owners demand money from Eskom of which Eskom doesn't pay any money if		

		the line is 11kV or 22kV because it's not a servitude, it's only a right of way. The right of way is not registered in Deeds Office. Sometimes the land owners (neighbours) are not in good terms. Sometimes the land owner doesn't know anything about the project, the reason for this is that he/she bought the farm and the previous owner didn't notify him/her about the wayleave agreement.		
Participant 5	Late release of funds	Late release of funds delays projects because the work cannot start as per schedule if the Purchase Order (PO) is not issued to the contractor.	Network Engineering and Design	Designer
	Unavailability of Surveyor General (SG) drawings	From electrification perspective, projects are delayed due to fact that Geographical Information System (GIS) department spends time trying to create the maps for areas where there is unavailability of SG diagrams.		
	Late delivery of material	Late material delivery always cause delays due to the fact that construction cannot proceed on site without the material components.		

		The Material Management department has a tendency of issuing wrong, and short materials to sites, and these construction sites are very far, and the wrong materials needs to be taken back to the stores which delays the projects.		
	Authorization contractors	The appointment of contractors that are not authorised to do the job in Northern Cape Operating Unit. One will find that the contractor is authorised to do Medium Voltage (MV), but not authorise for Low Voltage (LV), the problem arises when the contractor cannot carry on with work due to incomplete documentation. Contractors are also stopped on site due to incomplete safety file, contraventions of Occupational Health, and Safety Act, 1993		
	Incorrect cost estimates	The introduction of new bills two to three after the financial year. When the designs have been submitted based on the old bills causes delays, by getting quotations from the contractors which		

		creates double jobs from design perspective.		
	Unclear scope definition	From an infills perspective, wrongly linked information to a specific town or village cause delays. The engineers struggle to understand the project scope due to incorrectness of information displayed on maps.		
Participant 6	Poor communication	It is important for different departments to have channels/platforms of communication and regular meetings. Without communication, other departments/colleagues do not know what is it that the other department requires OR expected of them by others.	Network Planning	Actively Involved
	Lack of staff competency	Knowledge is built through formal and informal training. If other employees are more knowledgeable and they do not share their knowledge or do coaching on newer colleagues, then acquiring of skills/knowledge is delayed to the newer employees. A lot of colleagues do not know how to use ACNAC/K2. Due to this		

		fact, projects delay due to lack of movements in activities in CRA, DRA, ERA, FRA phases.		
	Environmental approvals	Department of Environmental Affairs is responsible to give Eskom approvals to build new HV lines and substations. Sometimes these approvals take time. Therefore, it is impossible to execute the project according to the schedule.		
	Lack of discipline	Lack of discipline can delay the agreed project delivery schedule. This is in two ways, firstly the delay may be caused by an individual doing a task due to complacency. Secondly, due to over-ambitious delivery schedule while in fact individuals involved know the challenges involved however do not want to be realistic. This is to avoid criticism and rather tow the line instead of being realistic. At the end of the day, the target is then not achieved due to this fact. And that then causes frustration to all involved		
	Financial constraints	Without funding departments cannot be fully resourced. NED /LD cannot start with work on		

		the projects as they cannot recover. Execution cannot appoint contractors and construct the asset. So funding is important.		
Participant 7	Scope changes or creep	Scope imprecision which needs clarification at execution phase results on major delays because alterations are done on site with contractor on site. Most of the time this results in additional material need to be acquired and cost escalation.	Network Planning	Actively Involved
	Lack of staff competency	In the Northern Cape Operating Unit, most of critical positions are filled by new staff with low level of competency or no experience in the project environment.		
	Financial constraints	Most projects in the Northern Cape Operating Unit get to execution stage without hundred percent funding being allocated to the project. This results in projects being deferred to the following financial years.		
	Poor communication between project team members	In the Northern Cape Operating Unit project teams don't communicate regularly when involved in a project. They normally don't have project progress meetings to		

		update all stakeholders involved.		
	Project risks identification & documentation	The project risks are not properly identified and track throughout the project life cycle. Project teams lose track of project risks that were identified at CRA and/ or DRA. The projects risks that are not managed in the project have the tendency of delaying the projects at execution stage.		
	Stringent procurement process	Eskom procurement processes contribute significantly to project delays in Eskom Northern Cape. The process design does not talk to the projects time lines its viewed and managed as an additional and separate work flow. Human competence factor also contribute to the slow procurement process in this regard.		
Participant 8	Community unrest	The increase number of stands in informal settlements during construction of the electrification projects can result in community unrest. The community members, and taxi association are not allowing contractors to transport their employees to local sites. They force	Electrification Planning	Actively Involved

		contractors working in local sites areas to subcontract some activities to them.		
	Poor communication	The communication breakdown between the community members, and local municipalities on planned projects.		
	Authorisation contractors	Most contractors that are on the new electrification contract are not authorised to work in Northern Cape Operating Unit. Some contractors on Panel A are not authorised, and task orders cannot be issued to them.		
	Incorrect material	Incorrect material delivered on site, which delays the project time as the material needs to be re-ordered in order to get the correct material for the project.		
	Lack of staff competency	Northern Cape Operating Unit employs new people and they are not adequately trained to deliver on the job. They need to be conversant with the processes, and application softwares required to execute the project deliverables.		
	Poor communication	Poor communication between contractors and project coordinators which results on the		

		project expectations not met or compromised.		
Participant 9	Weather conditions	If there are bad weather conditions this can result in contractors to stop working on site.	Operations and Maintenance	Actively Involved
	Unforeseen conditions	For an example, If the contractor is working on site and discovers that the area is rocky and was unprepared this can cause a delay on a project.		
	Leadership changes	Different leaders with different leadership styles and expectations. This has negative effects on team morale.		
	Environmental Approvals	The delays in approval of Environmental Impact Assessment (EIA), and Water Use Licence Authorization impact the delivery of engineering projects.		
	Design Changes	The design changes during project construction will affect the schedule, and increase project cost due to re-work activities.		
Participant 10	Weather Conditions	The project construction can be affected by rainy conditions which can also result in project escalation.	Network Engineering and Design	Designer
	Community Unrest	The communities can strike due to poor service delivery, and exclusion from current projects. The		

		contractor will not continue to construction for safety of employees.		
	Unavailability of material	The electrical material may require long lead times, and can also be delivered very late.		
Participant 11	Poor Planning	Poor planning results in late delivery of engineering designs with incorrect estimates which eventually delays projects.	Business Improvement and Performance Management	Actively Involved
	Financial Constraints	The projects in the Northern Cape are prioritized, and postponed due to financial constraints.		
	Lack of Business Partners	The absence of business partners in the Northern Cape Operating Unit delays projects, as priority is given to other Operating units.		
	Not following the Project Life Cycle Model	The project life cycle model is not effectively implemented.		
Participant 12	Late delivery of designs	The designs that are done at the year of execution are causing delays to the execution of projects.	Material Management	Actively Involved
	Late release of funds	The timelines from Capital Accounting to release funds takes too long.		
	ACNAC activities incorrectly linked	People names who are supposed to action activities are not linked. The controller has to move the projects manually.		

	Shortage of Material	Material department have a tendency of delivering short material to various sites. The project managers have a tendency of moving the material between sites without proper documentation. Projects are delayed due to short of material.		
	Stringent Procurement process	The timelines of procurement are extremely long to complete, and tender processes take too long as well.		
Participant 13	Design Changes	The design changes that are implemented without project manager's consent result in late delivery of project, and cost escalation that cannot be justified to the Investment Committee.	Capital Accounting	Actively Involved
	Poor contractor experience	The contractors in Northern Cape have a tendency of constructing with experience, without referring to the design drawings, and specification. This results the project delays when re-works are executed to address the identified defects.		
	Project scheduling not properly done	Some projects are not schedule in Northern Cape Operating Unit.		

Participant 14	Funding Constraints	Some projects are deferred to future financial years due to funding constraints.	Business Improvement and Performance Management	Actively Involved
	Environmental Approval	All projects in Northern Cape Operating Unit are delayed to outstanding Environmental Impact Assessment (EIA) approval.		
	Scope Creep	The additional scope to existing project scope can result in late completion of the project.		
	Late delivery of design	The design package can be delayed engineers do not have access to critical engineering software's, and lack of competency in utilising those tools.		
Participant 15	Human Resource Constraints	Projects in Northern Cape are delayed due to lack of resources.	Network Planning	Actively Involved
	Lack of funding	Projects lack funding, and cannot be executed. Most projects are not included in the budget.		
	Project Life Cycle not followed	The project managers tend to get involved in the project at the definition phase instead of initiation phase.		
	Poor planning	When poor planning is applied at the start of the project, it basically delays the entire project schedule.		
	Scope changes	The scope changes due to economic changes, the customers are forced to		

		change their initial plans for their projects, and opt cheaper alternatives.		
	Changes of business strategies	The cost saving initiative tends to compromise the quality of engineering designs, as engineers are restricted to visit sites, and eventually results in delays due to sub-standard designs.		
Participant 16	Organizational commercial and investment processes	The long lead materials are only ordered after an ERA form is approved by an Investment Committee, instead of design stage.	Project Execution	Decision Maker
	Human resource constraints	More resources are needed in engineering, and design, also project execution department. Resources ended up being overloaded, and other projects are packed or delayed.		
	Shortage of Material	There is always a shortage of material during execution which causes the contractor to wait. This results in project delays, and compensation events by the contractor.		
	Design Changes	Sometimes the construction of assets may not be the same as the design drawings. This leads to changes that should be done to correct defects.		

	Poor Communication	Unclear communication on how to implement cost saving initiatives may lead to poor quality of designs executed by our design engineers, which will result in project delays during the construction phase of the project.		
Participant 17	Project Life Cycle Model not followed	The project managers get involved at the definition phase of the project instead of initiation phase.	Network Engineering and Design	Designer
	Economic changes	The economic climate change can cause the customers to deviate from the original scope, which delays the execution of the project.		
	Inconclusive geotechnical studies	The inconclusive geotechnical studies affect the material selection during the design process.		
Participant 18	Lack of staff competency	The employees in Northern Cape are new, and this affect the quality of engineering deliverables	Network Engineering and Design	Designer
	Politics	Politics may play a major role in electrification projects. Electrification lists may exclude members of a certain political parties.		
	Human resources constraints	Human resource constraints in Asset Creation department space creates a lot of		

		challenges, and delays projects.		
	Politics	In electrification projects, politics play a major role.		
	Budget cuts	Eskom has lately implemented budget cuts which in turn affect the delivery of projects.		
	Environmental Approvals	The Environmental Impact Assessment (EIA), and environmental projects really affect, and delay projects in a big way.		
Participant 19	Leadership changes	The employees have not been happy lately due to leadership changes, which create uncertainties in their career paths. This has also affected staff morale, and productivity. There has been a lack of direction in the past few months in Asset Creation space due to numerous changes in leadership.	Network Planning	Actively Involved
	Design reviews not conducted	Engineering section does not conduct design reviews to minimise design changes during construction.		
	Procurement process	Project services load reservation number, and dates for the material. Project managers are not in control of the process.		
	Lack of staff competency	Most employees in the Operating Unit are not competent. People are working in project		
Participant 20			Project Execution	Decision Maker

		management department just for promotion purposes.		
	Unforeseen conditions	The rocks are discovered during construction stage of projects.		
	Ineffective organisation Structures	Engineering personnel focus on their special functions. For an example, the primary design engineer is only responsible for primary design. Project teams do not report directly to the project manager.		
Participant 21	Servitude and Wayleave Approvals	Difficult land owners may refuse to sign the wayleave agreement. The land owner may refuse the proposed route for the powerline due to past experience on the existing powerlines. The un-surveyed land where the land owner is unknown results delays in the registration of such land. There is a lot of IPP projects in Northern Cape, these IPP's do not compensate the landowners, so they expect to be compensated by Eskom.	Land Development	Designer
	Death of land owners	The project is delayed in process of identifying the beneficiaries in order to proceed with the registration of servitude.		

Participant 22	Budget cuts in the middle of financial year	The budget cuts, in the middle of a financial year result in project delays because when the budget changes, the plans have to be re-approved as per the new budget, and this takes a lot of time.	Network Planning	Actively Involved
	Authorisation contractors	Contractors are awarded contracts without the necessary the authorization, and this cause delays on projects as these contractors cannot establish site, and working without authorisation.		
	Stringent procurement process	The stringent procurement processes are sometimes a major challenge in procuring resources as well as material e.g. transformers can only be ordered at ERA stage and their lead times is 8-12 months.		
	Servitude and wayleave approvals	Some projects have been delayed by this, as some farm owners are now asking to be paid for wayleaves, and sometimes after a route has been chosen, they go build on it just before the project commences.		
	Water Use Licence Authorization	Some projects require a Water Use Licence Authorization (WULA) from the department of water, and environmental		

		affairs. This sometimes takes too long to be resolved, and cause delays on projects.		
	Soil nomination test	The soil nomination tests that are not done in time, and left till late in the project. They can cause major delays, and escalate the project costs. To get approvals for the escalated cost takes time.		
Participant 23	Financial constraints	Capex budget keeps on being reduced, and that affect the scope of the project. Some projects may be lost in the system due to inactivity.	Network Planning	Actively Involved
	Lack of following processes	The project life cycle model training was very high level. The implementation of PLCM in the entire OU is not adequate.		
	Lack of resources	There is a lack of human resources in Northern Cape including external contractors.		
	Politics	Politics mainly affect the electrification space. The municipal member's affiliations (ANC vs DA vs EFF) can result in project delays.		
	Remote and vast area	The Northern Cape is geographically big, and areas are remote. Hence a lot of time is spent on travelling which impact the delivery of projects.		

	Lack of staff competency	The OU is struggling to retain its employee, Employees are leaving due to various reasons (family, lifestyle, cost of living etc.). When someone vacates the post, it takes times to do replacement, or the new person will take to get up to speed with projects that are left behind		
Participant 24	Financial constraints	The cost saving strategies have resulted planners to be restricted to go to site which affects the quality of planning proposal.	Customer Network Services Centre	Client
	Scope changes	Due to poor quality of planning proposals, the engineers have to spend a lot of time amending the proposed scope which delays the delivery of final design packages.		
Participant 25	Environmental approvals	Eskom has a lot of red tape when it comes to EIA approvals. For an example, the EIA may be on hold due to a water use licence which takes approximately two years to be approved.	Network Engineering and Design	Actively Involved
	Community unrest	It is extremely difficult to connect everybody to the national grid in the village under one project. This results in protests, and vandalism of project material which delays the		

		construction of the project.		
	Project Life Cycle Model not followed	There is tendency of executing projects in Northern Cape by taking short cuts.		
	Human resources constraints	Eskom NCOU is the most understaffed OU in the country. You find that one individual is doing 3 people's work.		

Table 4-2: The identified delay factors by Eskom participants as part of Idea generation phase.

4.3 Idea Clarification

A total of 112 delay factors were identified during the idea generation process as illustrated in Table 4-2. Warfield and Cardenas (2002) suggested that the Interactive Management group workshop may comprise of 6 to 12 individuals with issue related expertise in order to maintain a good debate. Warfield and Cardenas (2002) argued that it is imperative for the Interpretive structural modelling group process to secure the participation of representatives from each stakeholder roles otherwise the quality of IM outputs might be compromised. This research study managed to secure the participation of 10 respondents which represent the client, designer, decision maker and actively involved stakeholders as depicted in Table 4-3 below. The passively involved stakeholders were not requested to participate in an IM group workshop as discussed in section 4.1.5.

The attendees of interpretive structural modelling workshop comprised of one manager from Customer Network Centre department, one senior engineer from Network Engineering and Design department, one manager from Land Development department, one senior manager and one project manager from Project Execution department, one senior engineer from Plant Management department, one senior engineer from Network Planning department, one senior engineer from Electrification Planning department, one manager from Material Management department, and one manager from Capital Accounting department.

Stakeholder's role	Stakeholder's Department	Number of Participants per department
Client	Customer Network Centre	1
Designers	Network Engineering and Design	1
	Land Development	1
Decision Maker	Project Execution	2
Actively Involved	Plant Management	1
	Network Planning	1
	Electrification Planning	1
	Material Management	1
	Capital Accounting	1

Table 4-3: The Interactive Management(IM) workshop participants.

The IM group comprising of 10 participants clarified and merged the list of generated delay factors where necessary. The description of each delay factors assisted a lot in grouping the identified factors. For an example, some participants indicated that projects in Northern Cape Operating Unit are delayed due to either water use licence authorization (WULA) or environmental impact assessment (EIA), these two factors were grouped as environmental approvals. A total of 112 identified factors were reduced to 44 factors after clarification, and merging processes.

The 44 reduced delay factors were further reduced to 26 delay factors in order to minimise modelling time during the session. The group participants were requested to select four delay factors that they perceived to be significant. The total frequency column represents the total number of participants who selected same identified delay factor as significant. Table 4-4 below depicts a list of 18 significant delay factors that were voted by only one participant in a group. These 18 delay factors were automatically excluded from the list of significant delay factors. Therefore, they were not used in the interactive structural modelling process.

No	Delay Factor	Description of delay factor	Total frequencies
D1	Incorrect project classification	The completion of self-build projects in the capital environment is delaying the projects. The minor works should be the platform to run self-built projects	1
D2	Poor contractor experience	The contractors in the Northern Cape have a tendency of constructing with experience, without	1

		referring to the design drawings, and specification. This results in project delays when re-works are executed to address the identified defects.	
D3	Adherence to policies, and standards	Projects in NCOU have to follow process in terms of work flow. Electrification projects cannot proceed if the change control forms are not signed by the department of energy. The project cannot be presented to the investment committee.	1
D4	Unavailability of material	The electrical material may require long lead times, and can also be delivered to Eskom very late.	1
D5	Incorrect drawings	Contractors are expected to have access to Eskom DT website to download all standards, and specifications. Contractors end up using outdated drawings due to access issues, which delays projects. Projects are delayed when the contractor conducts re-work in order to conform to the latest standards.	1
D6	Breakage of equipment	The drills get damaged when drilling rocks on site. This delays the construction of the project.	1
D7	Incorrect estimates	When the designs have been submitted based on the old bills causes delays, by getting quotations from the contractors which creates double jobs from design perspective.	1
D8	Lack of discipline	Lack of discipline can delay the agreed project delivery schedule. This is in two ways, firstly a delay may be caused by an individual doing a task due to complacency. Secondly, due to over-ambitious delivery schedule while in fact individuals involved know the challenges involved however do not want to be realistic. This is to avoid criticism and rather than being realistic. At the end of the day, the target is then not achieved due to this fact. And that then causes frustration to all involved	1
D9	Project risk not identified	The project risks are not properly initiated and tracked throughout the projects life cycle. Project teams lose track of project risks that were identified at CRA and/ or DRA. The projects risks that are not managed in the project have the tendency of delaying the projects at execution stage.	1
D10	Organisational and investment processes	The long lead materials are only ordered after an ERA form is approved by an Investment Committee, instead of design stage.	1
D11	Lack of business partners	The absence of business partners in the Northern Cape Operating Unit delays projects, as priority is given to other Operating units.	1
D12	ACNAC activities not linked	The names of people who are supposed to action activities are not linked. The controller has to move the projects manually.	1
D13	Weather conditions	The project construction can be affected by rainy conditions which can also result in project escalation.	1
D14	Economic changes	The economic climate change can cause the customers to deviate from the original scope, which delays the execution of the project.	1
D15	Inconclusive geo-technical studies	The soil nomination tests that are not done in time can cause major delays.	1
D16	Death of landowners	The project is delayed in process of identifying the beneficiaries in order to proceed with the registration of servitude.	1

D17	Remote and vast areas	The Northern Cape is geographically big, and areas are remote. Hence a lot of time is spent on travelling which negatively impact the delivery of projects.	1
D18	Design reviews not conducted	The design reviews are not conducted by engineering design section in order to minimise design changes during construction.	1

Table 4-4: The significant delay factors that were voted by one participant only in a group.

Table 4-5 below illustrates a list of 26 identified significant delay factors that were voted by more than one group participants. It is interesting to note that delay factor “financial constraints” is the most significant element voted by 10 group participants.

No	Delay Factor	Description of delay factor	Total frequencies
D1	Financial constraints	Most projects in the Northern Cape Operating Unit are prioritized, and get to execution stage without hundred percent funding being allocated to them. This results in projects being deferred to the following financial years.	10
D2	Project life cycle model not followed	The project managers in Northern Cape get involved at the definition phase of the project instead of initiation phase. The stakeholder input meetings, project scheduling is not done sometimes, and there is a tendency of executing projects by taking short cuts.	6
D3	Poor communication	Poor communication between contractors and project coordinators can results on the project expectations not met or compromised. Unclear communication on how to implement cost saving initiatives may lead to poor quality of designs executed by design engineers, which can result in project delays during the construction phase of the project.	6
D4	Lack of staff competency	The most critical positions in Northern Cape Operating Unit are filled by new staff with low level of competency or no experience in the project environment. They are not conversant with the processes, and application softwares required to produce the project deliverables. People are working in project management department just for promotion purposes.	6
D5	Human resource constraints	Eskom NCOU is the most under-staffed OU in the country. Resources ended up being overloaded, and other projects are packed or delayed. More resources are needed in design engineering, and also project execution department. Currently in Network Engineering & Design which is responsible for DRA phase of a project life cycle model. There is only one draughts personnel, no Civil engineer, No Senior Design Engineers for MV/LV, and HV Lines.	5
D6	Environmental approvals	The new substations require an environmental impact assessment (EIA) approval. The project should have tree cutting permits if there are trees to be cut. If the line runs across the river, then Eskom will need to apply for Water Use Licence Authorization (WULA) which takes approximately two years to be approved.	5
D7	Stringent procurement processes	The stringent procurement processes are sometimes a major challenge in procuring resources as well as materials e.g. transformers can only be ordered at ERA stage and their lead times is 8-12 months. The	4

		procurement process design does not talk to the project time lines, it is viewed and managed as an additional and separate work flow.	
D8	Poor planning	When poor planning is applied at the initiation stage of the project, it basically delays the entire project schedule. Poor planning also results in late delivery of engineering designs with incorrect estimates which eventually delays projects.	4
D9	Community unrest	The communities can strike due to poor service delivery, and exclusion from current projects under construction on site. It is extremely difficult to connect everybody in the village or township under one project. This can result in protests, and vandalism of project material, and electrical infrastructure. Therefore, the contractor will not continue with construction for safety of employees.	4
D10	Servitude and Wayleave approvals	Difficult land owners may refuse to sign the wayleave agreement, and the proposed route for the powerline due to past experience on the existing powerlines. The un-surveyed land where the land owner is unknown results delays in the registration of such land. There is a lot of IPP projects in the Northern Cape, these IPP's do not compensate the landowners, so they expect to be compensated by Eskom.	4
D11	Late delivery of material	Late material delivery always cause delays due to that construction cannot proceed without the material components on site. The Material Management department has a tendency of issuing wrong, and short materials to sites.	3
D12	Authorization of contractors	Contractors are awarded contracts without the necessary authorization, and this causes delays on projects as these contractors cannot establish site, and working without authorisation. Some contractors on Panel A are not authorised, and task orders cannot be issued to them.	3
D13	Scope creeps	Scope imprecision which needs clarification at execution phase results on major delays because alterations or additions are done on site with contractor on site. Most of the time this results in additional material that needs to be acquired and can result in cost escalation.	3
D14	Design changes	Sometimes the constructed assets may not be the same as the design drawings or contractor can change the design without engineer's consent. This leads to changes that should be effected to correct defects.	3
D15	Politics	The politics play a major role in electrification projects. Electrification lists may exclude members of a certain political party. The municipal member's affiliations (ANC vs DA vs EFF) can result in project delays.	3
D16	Unavailability of Surveyor General (SG) diagrams	From an electrification perspective, projects are delayed due to fact that Geographical Information System (GIS) department spends time trying to create the maps for areas where there is unavailability of SG diagrams. The design engineers for electrification are forced to pick up co-ordinates for each stand on site, which delays the detailed engineering design delivery date.	2
D17	Unclear scope definition	Most of refurbishment projects are delayed on execution phase due to overlooked scope of work e.g. implementation plan that is not clear in terms of needed outages during construction.	2

D18	Shortage of Material	Material department have a tendency of delivering short material to various sites. The project managers have a tendency of moving the material between sites with proper documentation.	2
D19	Project scheduling not properly done	Some projects are not scheduled at all in Northern Cape Operating Unit.	2
D20	Late release of funds	Late release of funds delays projects because the work cannot start as per schedule if the Purchase Order (PO) is not issued to the contractor.	2
D21	Unforeseen conditions	The rocks are discovered during construction stage of projects.	2
D22	Late delivery of designs	The design package can be delayed when the engineers have no access to the critical engineering software's, and lack of competency in utilising those tools.	2
D23	Change of business strategies	The cost saving initiatives are compromising the quality of engineering designs, as engineers are restricted to visit sites, and eventually results in delivery of sub-standard designs, and project delays.	2
D24	Ineffective organisational structures	Eskom engineering personnel are focusing on their special functions. For an example, the primary design engineer is only responsible for primary design. The project teams do not report directly to the project managers.	2
D25	Leadership changes	The employees have not been happy lately due to leadership changes, which creates uncertainty in career paths. This has also affected staff morale. There has been a lack of direction in the past few months in Asset Creation space due to numerous changes in leadership.	2
D26	Incorrect material	Incorrect material delivered on site delays project time as the material needs to be re-ordered.	2

Table 4-5: The significant delay factors that were voted by more than one participants

The 26 significant delay factors will be utilised in the interactive structural modelling process as discussed in section 3.6.2, and they will be assessed if the interrelationships exist amongst them.

4.4 Idea Structuring Phase-ISM Model

A total number of 10 participants attended the interpretive structural modelling workshop as discussed in section 4.3. The group consisting of 6 to 12 participants with issue-related expertise is adequate for an Interpretive Structural Modelling workshop (Warfield and Cardenas, 2002). The participants were given the list of 26 significant delay factors, and their description identified during the idea clarification process as depicted in Table 4-5. This was done to increase group understanding on

identified elements, and buy-in of proposed solutions during the interpretive structural modelling workshop.

A list of 26 significant action ideas were loaded on Concept Star software as illustrated in Figure 4-4. The Interpretive Structural Model (ISM) application tool on the software was selected to construct the relationship model of project delay factors. The triggering question loaded on Concept Star software was, “what are the main factors that cause late completion of electrical distribution projects at Eskom Northern Cape Operating Unit?”

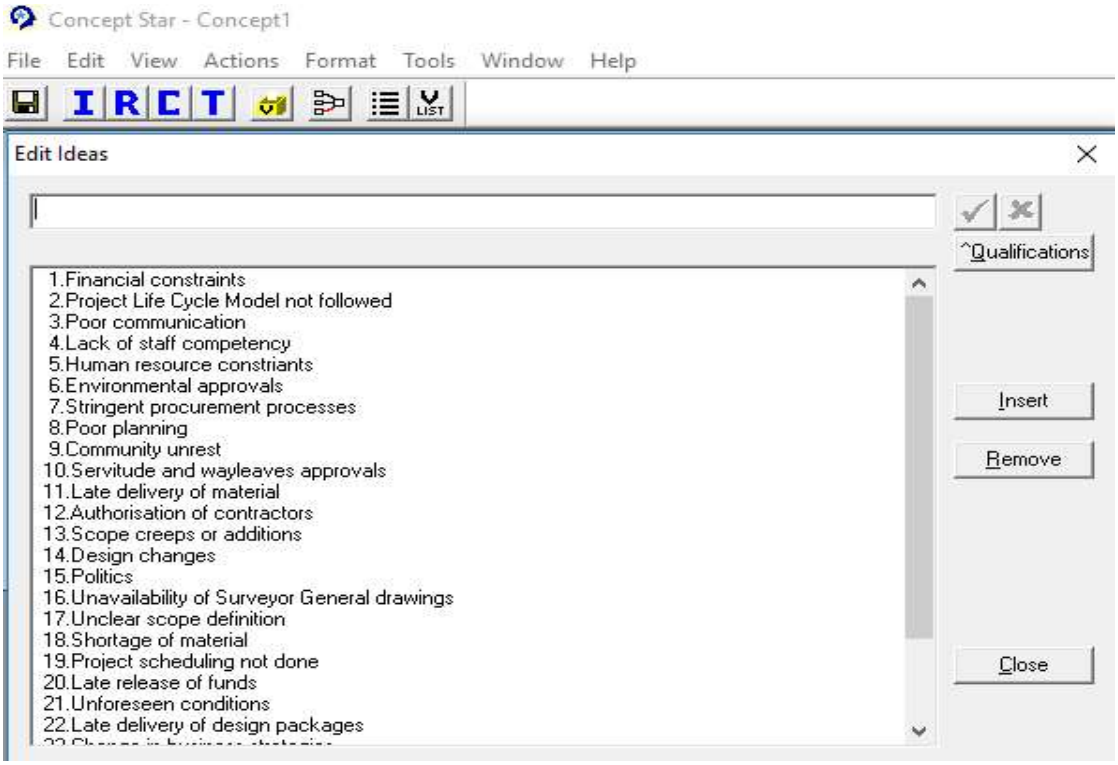

Figure 4-4: List of identified elements that were loaded on Concept Star software

The relation phrase “significantly leads to” was loaded on the software Concept Star software to determine the meaning of the links in the relationship model. The Concept Star software represented a series of statements whether or not a relationship exists between the pair of ideas. The software posed questions such as does “element A significantly leads to element B?”(Tuan, 2004). The Concept Star displayed the relationships between A and B elements, starting from lower to higher numbered ideas. For each pair of ideas, the group discussions were held in order to reach a consensus whether the relationship between pairwise elements is either Yes or No.

Figure 4-5 illustrates the screen displayed during the voting activity used by group participants to analyse the relationship between pairs of ideas (Sorach, 2014).

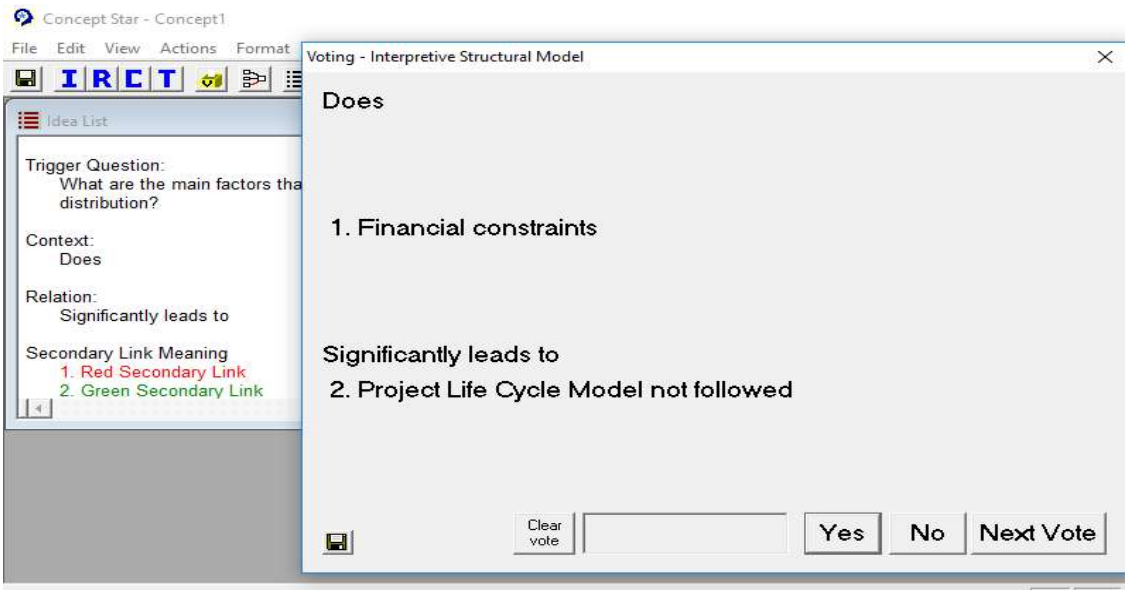

Figure 4-5: Example of voting screen from Concept Star software during IM workshop

The group participants assessed the relationships amongst the elements causing delays in the delivery of electrical distribution projects at Eskom Northern Cape Operating Unit. The voting process continued iteratively until all responses by participants were processed by Concept Star software. Table 4-6 represents a total of 95 votes that were recorded by Concept Star software during an IM workshop.

1) 1---> 2 Yes	20) 8---> 1 Yes	39) 12--->10 No	58) 17---> 3 No	77) 21---> 3 No
2) 2---> 1 Yes	21) 3---> 8 Yes	40) 1--->13 Yes	59) 17--->12 No	78) 21--->12 No
3) 1---> 3 No	22) 8---> 3 Yes	41) 13---> 1 Yes	60) 1--->18 Yes	79) 17--->21Yes
4) 3---> 1 Yes	23) 1---> 9 Yes	42) 1--->14 Yes	61) 18---> 1 No	80) 21--->17Yes
5) 1---> 4 Yes	24) 9---> 1 Yes	43) 14---> 1 Yes	62) 5--->18 No	81) 1--->22 Yes
6) 4---> 1 Yes	25) 1--->10 Yes	44) 1--->15 Yes	63) 18---> 5 No	82) 22---> 1 Yes
7) 1---> 5 Yes	26) 10---> 1 No	45) 15---> 1 Yes	64) 18---> 6 No	83) 1--->23 Yes
8) 5---> 1 No	27) 5--->10 Yes	46) 1--->16 Yes	65) 18--->10 No	84) 23---> 1 Yes
9) 1---> 6 Yes	28) 10---> 5 No	47) 16---> 1 No	66) 12--->18 No	85) 1--->24 Yes
10) 6---> 1 No	29) 6--->10 No	48) 5--->16 Yes	67) 18--->16 No	86) 24---> 1 Yes
11) 5---> 6 Yes	30) 10---> 6 No	49) 16---> 5 No	68) 1--->19 No	87) 1--->25 Yes
12) 6---> 5 No	31) 7--->10 No	50) 6--->16 No	69) 19---> 1 Yes	88) 25---> 1 Yes
13) 1---> 7 Yes	32) 1--->11 Yes	51) 16---> 6 No	70) 3--->19 Yes	89) 1--->26 No
14) 7---> 1 No	33) 11---> 1 Yes	52) 7--->16 Yes	71) 19---> 3 Yes	90) 26---> 1 No
15) 5---> 7 Yes	34) 1--->12 No	53) 10--->16 No	72) 1--->20 Yes	91) 3--->26 Yes
16) 7---> 5 No	35) 12---> 1 No	54) 12--->16 No	73) 20---> 1 Yes	92) 26---> 3 No
17) 6---> 7 No	36) 3--->12 Yes	55) 1--->17 No	74) 1--->21 No	93) 26--->12 No
18) 7---> 6 Yes	37) 12---> 5 No	56) 17---> 1 Yes	75) 21---> 1 Yes	94) 17--->26 No
19) 1---> 8 No	38) 12---> 6 No	57) 3--->17 Yes	76) 3--->21 Yes	95) 26--->17 No

Table 4-6: the votes recorded by Concept Star during the IM workshop

After the participants completed the voting analysis, and decisions, Concept Star software constructed the final unformatted ISM relationship model. The ISM model was formatted by moving, and re-sizing the boxes to make its interpretation easier. The ISM model was further formatted using Microsoft Visio Professional 2013 as depicted in Figure 4-6 below and finally distributed to the IM group participants for verification and acceptance.

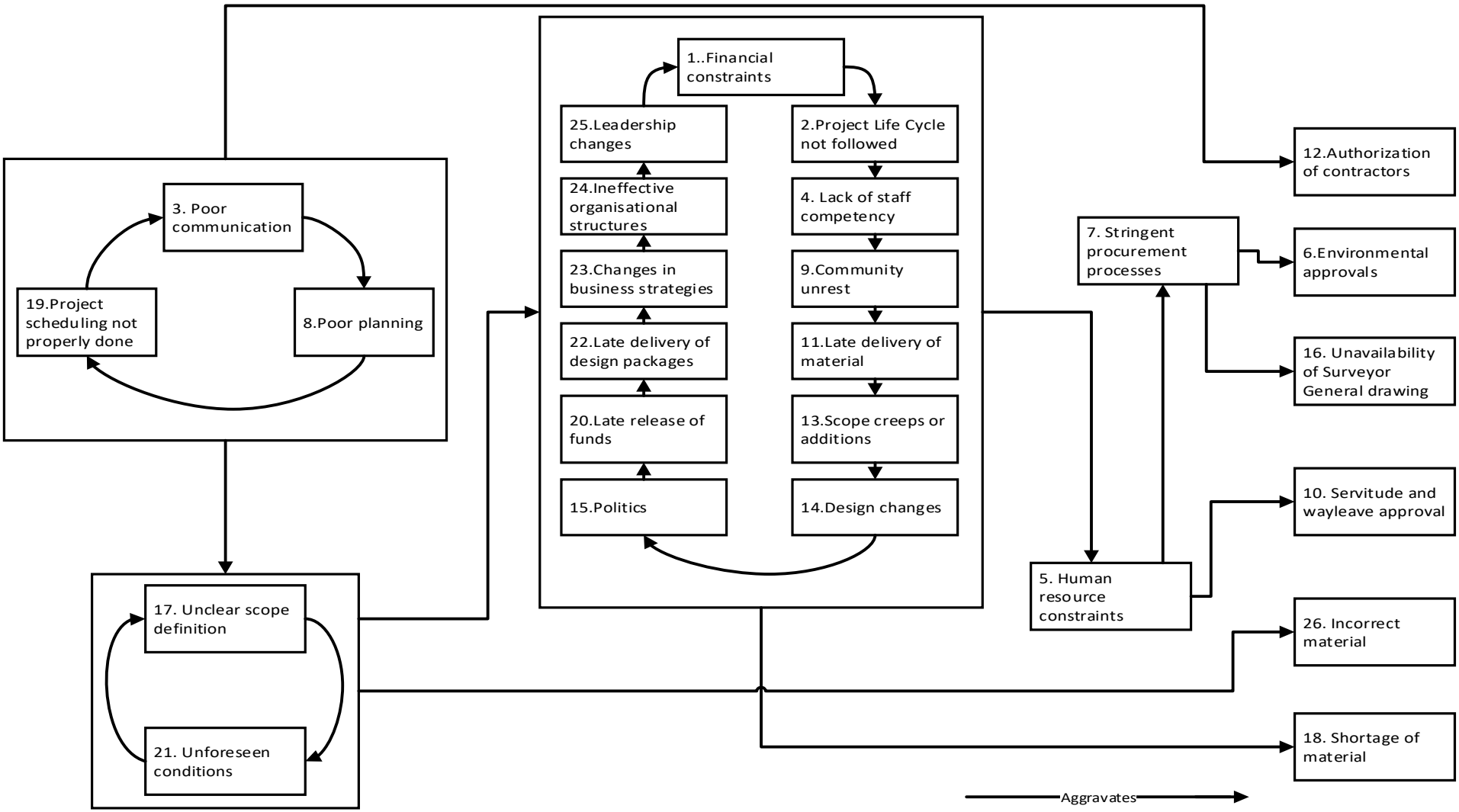

Figure 4-6: ISM Model of factors causing delays in electrical distribution projects at Eskom Northern Cape Operating Unit.

4.5 Interpretation of ISM Model

The ISM model depicted in Figure 4-6 illustrates the relationship between the factors causing delays in electrical distribution projects at Eskom Northern Cape Operating Unit. The ISM model has discovered the interrelationships between the delay factors which would not have been understood or achieved by analysing the factors individually. The delay factors are illustrated in boxes with arrows that represent the direction of strong or significant relationship that exists between them (Sorach, 2014). There are no arrows between the boxes where the relationship between the elements does not exists. The delay factors in the same box illustrates that there is a circular relationship between them. For an example, element D17 significantly leads to element D21, and element D21 significantly leads to D17. The delay factors D3, D8, and D19 in the box on the far left of the ISM model are the elements that have powers to influence the others.

The ISM model depicts that the three primary or main delay factors that cause late completion of electrical distribution projects are as follows:

- Poor communication (D3)
- Poor planning (D8)
- Project scheduling not properly done (D19)

These delay elements are not influenced by the other identified factors that result in the late delivery of electrical engineering projects at Eskom distribution. During the voting session when the interrelationships between the elements were assessed using Concept Star software, the participants voted “yes” that “Poor communication D3” significantly aggravates “Poor planning D8”, and vice versa. The participants also voted “yes” that “poor communication D3” significantly aggravates “project scheduling not properly done D19”, and vice versa.

Concept Star determined that “Poor planning D8” significantly aggravates “project scheduling not properly done D19”, and vice versa based on logical inferences from other votes. The participants argued that it is imperative for different departments in the Northern Cape Operating Unit to have channels or platforms of communication, and possibly regular meetings. The project stakeholders from various departments can easily misunderstand the common project objectives or expectations due to “poor

communication D3". The participants argued that most projects in Northern Cape Operating are initiated without proper planning, and project managers are not involved at the initiation phase of the projects. The Eskom participants alluded that "Poor planning D8" results in "project scheduling not properly done D19" because project managers don't get involved during the initiation phase of projects. It is interesting to note that the element "project scheduling not properly done D19" correlates with the survey data collected from Eskom participants as discussed in section 4.2.4. A total of 23 out of 25 participants indicated that project scheduling is not done in Northern Cape Operating Unit.

From the ISM model, "poor communication D3" was found to significantly influence the element "authorization of contractors D12". Concept Star determined that the elements "poor planning D8", and "project scheduling not properly done D19" significantly influence the element "Authorization of contractors D12" based on logical inferences from other votes. The participants argued that contractors are not adequately informed of the requirements for authorization processes due to "poor communication D3". Contractors are stopped, and removed from construction sites by the Safety, and Health Officials due to incomplete safety files, and contraventions of Occupational Health, and Safety Act, 1993. The participants alluded that some contractors can be authorised to do Medium Voltage (MV) work, but not authorized to do Low voltage (LV) work which create challenges when the project comprises of both MV, and LV activities.

As discussed in section 2.1, project schedule management involves the processes required to manage timely completion of the project. The project schedule management includes the processes to define activities, sequence of activities, estimate activity resources, and estimate durations in combination with the scheduling tool to produce the schedule model (PMBOK, 2013). Therefore, Eskom project managers have to ensure that schedule management plans are prepared for electrical engineering projects.

Project managers spend most of their time communicating with team members and internal or external project stakeholders (PMBOK, 2013). It is imperative for the project managers to identify the stakeholders early in the project or phase, and to analyse the level of interests, their individual expectations, and their influences (PMBOK, 2013). Effective communication creates a bridge between diverse stakeholders who may

possess different organisational, and cultural backgrounds, different levels of expertise, different interest, and perspective, which have influence on the projects deliverables (PMBOK, 2013). Therefore, Eskom project managers should engage stakeholders effectively to understand needs, and expectations, addressing issues as they occur, managing conflicting interests in order to achieve project objectives.

From the ISM model, “poor communication D3” was found to directly influence “unclear scope definition D17” and “unforeseen conditions D21”. The participants argued that poor communication between the project stakeholders can result in poorly defined scope of works. The unforeseen conditions such as rocks can be discovered during the implementation phase of the projects. The participants alluded that “unclear scope definition D17”, and “unforeseen conditions D21” can deviate the project from its schedule, and also escalate project costs. Since “poor communication D3”, “poor planning D8”, and “project scheduling not properly done D19” are the elements related in a circular fashion. Concept Star determined that “poor planning D8” significantly aggravates “unclear scope definition D17”, and “unforeseen conditions D21”. Concept Star also determined that “project scheduling not properly done D19” significantly leads to “unclear scope definition D17”, and “unforeseen conditions D21” based on logical inferences from other votes.

The six delay elements at the far right of the hierarchy namely “authorization of contractors D12”, “environmental approvals D6”, “unavailability of surveyor general (SG) drawings D16”, “servitude and wayleaves approvals D10”, “incorrect material D26”, and “shortage of material D18” are delay elements mostly influenced by others. These elements have no power to influence other delay elements.

4.5.1 Comparison of Research Findings and Nominal Group Technique results

From Table 4-5, the delay element “environmental approvals D6” was voted by 5 participants as an insignificant factor that cause delays in the delivery of electrical distribution projects. The nominal group technique result on element “environmental approvals D6” correlated with the output of an Interpretive Structural Model. It is interesting to note that the element “environmental approvals D6” is not a significant delay factor of electrical distribution projects based on ISM model in Figure 4.6.

Affairs (2010) stipulates that the Department of Environmental Affairs (DEA) shall respond to an Environment Impact Assessment (EIA) report received from an appointed Environmental Assessment Practitioner (EAP) within 60 days, whether the EIA report is accepted or rejected. The timeframes for Environmental Impact Assessments (EIA) and Water Use Licence Authorisation (WULA) can be included in the project scheduling processes during the planning phase of the electrical distribution projects. Therefore, the environmental approvals are not the cause delays in the delivery of electrical distribution projects at Eskom Northern Cape Operating Unit.

From Table 4.5, the delay elements “Project life cycle model not followed D2” and “lack of staff competency D1” were both voted by six group participants during the Nominal Group Technique process as the insignificant factors that cause late completion of electrical distribution projects. It is interesting to note that the elements “project life cycle model not followed D2” and “lack of staff competency D1” are not the main delay factors of electrical distribution projects based on the ISM model in Figure 4-6. These elements are positioned in level three of the ISM model but they are related in a circular manner

The delay element “Financial constraints D1” was voted by 10 group participants as the most significant factor that cause late delivery of electrical distribution projects as illustrated in Table 4-5. It is interesting to note that the element “financial constraints D1” is not the main delay factor of electrical distribution projects based on the ISM model in Figure 4-6. From Table 4-5, the delay element “poor communication D3” was voted by six group participants during the idea clarification stage which illustrates that it is not a major driver causing delays. It is interesting to note that delay factor “poor communication D3” was found to be the key delay factor of electrical distribution projects at Eskom Northern Cape Operating Unit as depicted in Figure 4.6. The discrepancy between the two results reveals that when participants examine the interrelationships between system elements through IM, they draw a different conclusion.

4.5.2 Comparison of Research Findings and Literature Review

The element “Improper planning by contractors” was identified as the significant delay factor by 9 researchers in various regions as discussed in the literature review in section 2.4. “poor site management” was identified by ten researchers in various regions as depicted in Table 2-7. These delay factors can be linked to the delay element “poor planning D8” identified in this research study.

The delay element “poor communication between parties” was identified by six researchers from various regions as discussed in the literature review. This delay factor can be linked to the delay element “poor communication (D3)” identified in this research study.

From Table 2-7, the delay elements “mistakes during construction” and “change of orders” were both identified by five researchers in the literature review. The delay elements “mistakes during construction”, “Change of orders” can be linked to the delay element “unclear scope definition D17” depicted in Figure 4.6. The delay element “design variations or changes” was identified by fourteen researchers as the main factor that cause project delays. It is interesting to note that the element ““Design variations or changes” is not the main delay element of electrical distribution projects. This delay element is positioned in level three of the ISM model and can be influenced by other delay elements positioned in level two.

From Table 2-7, the delay element “unforeseen conditions” was identified by four researchers in the literature review. The research study has identified that the element “unforeseen conditions D21” is not the main delay factor and can be influenced by other factors based on the ISM model.

The research study has revealed that some delay factors are unique to electrical distribution projects at Eskom Northern Cape Operating Unit, and could not be linked with any delay factors identified by other researchers in the literature review. These delay factors include “project life cycle model not followed D2”, “environmental approvals D6”, “servitude and wayleave approvals D10”, “authorization of contractors D12”, “politics D15”, “unavailability of surveyor general (SG) drawings D16”, “project scheduling not properly done (D19)”, “change in business strategies D23”, “ineffective organisational structures D24”and “leadership changes D25”.

CHAPTER 5: RESEARCH CONCLUSIONS

5.1 Review of Research Aim and Objectives

In order to conclude appropriately, it is imperative to revisit the reasoning behind conducting the research study to ensure that the summary and the conclusion are in accordance with the aim and objectives. The three key questions posed for this research study were as follows: -

a) *What are factors that cause late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit?*
b) *What are the key drivers or root causes of late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit?*
c) *What are the interrelationships between factors that cause project delays?*

A total of five research objectives were set in order to respond to the above-mentioned questions and are discussed below:

1. *To identify factors that contribute to late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit.*

The Interactive management (IM) methodology was adopted in this research study for the identification of project delay factors in electrical distribution projects at Eskom Northern Cape Operating through the use of the idea generation, idea clarification and interpretive structural modelling technique. The research survey identified a total of twenty six delay factors that contribute to late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit. The identified project delay factors are depicted in Table 4-6.

2. *To analyse the identified project delays factors and determine the key drivers or root causes of late delivery of electrical distribution projects.*

Interpretive structural modelling workshop consisting of 10 participants was used to structure project delay factors identified during idea generation, and clarification processes. The Interpretive Structural Modelling software (Concept Star) was used to analyse whether or not a relationship exists between the pair of identified elements. The ISM model in Figure 4-6 revealed that the three key or main delay factors that

cause late delivery of electrical distribution projects at Northern Cape Operating Unit were as follows:

- Poor communication
- Poor planning
- Project scheduling not properly done

The three primary delay elements were found to influence each other, but were not influenced by the other identified factors. It was interesting to note that the delay element “project scheduling not properly done” from the ISM model correlated with the survey data collected from Eskom participants as discussed in section 4.2.4. A total of 23 out of 25 participants indicated that project scheduling is not properly done at Eskom Northern Cape Operating Unit.

3. *To determine interrelationships between the identified delay factors of electrical distribution projects.*

The following conclusions were reached pertaining to the interrelationship between the identified delay factors at Eskom Northern Cape Operating Unit: -

- From the ISM model in Figure 4-6, three delay factors (12%) and two delay (7%) factors are positioned in level one and level two respectively. The identified elements in level one are the root causes of delays in the delivery of electrical distribution projects at Eskom Northern Cape Operating Unit.
- Thirteen delay factors (50%) are positioned in level three of the model, and there is circular feedback loop between them. This implies that when solving one element in the loop can lessen the impact on other elements in the loop (Nthunya *et al.*, 2017).
- Six delay factors (23%) are positioned in level six of the model and have no powers to influence others factors. These identified elements are not the root causes of project delays in electrical distribution projects.

4. *To determine whether the correlations or gaps exist between the identified delay factors from this research study and literature review.*

It is noteworthy that various researchers from various regions identified the significant delay factors that contribute to late delivery of projects. But according to the ISM model, some of these delay factors are not the major causes of delays in electrical distribution projects. For an example, the delay element “design variations or changes” was identified by fourteen researchers as the major factor that cause project delays. From the ISM model “design variations or changes” is not the main root cause of project delays in electrical distribution projects. A total of ten project delay factors (refer to section 4.6.2) were found to be unique to electrical distribution projects at Eskom Northern Cape Operating Unit, and could not be linked with any delay factors identified by other researchers in the literature review.

5. *To recommend the corrective measures that Eskom Northern Cape Operating Unit may apply in mitigating project delays on electrical distribution projects.*

From the ISM model in Figure 4-6, the three project delays positioned at the far left or in level one can significantly aggravate the other project delay factors. The impact on the other project delay factors can be reduced or mitigated if the root causes of project delays in electrical distribution projects are addressed. It is recommended for Eskom Northern Cape Operating Unit to focus on addressing the elements in level one namely “Poor communication”, “poor planning”, and “project scheduling not properly done”. It imperative for different departments in the Northern Cape Operating Unit to have channels or platforms of communication, and possibly regular meetings in order to avoid misunderstanding of common project objectives or expectations.

5.2 Research Limitations

Warfield and Cardenas (2002) recommended that the Interpretive Structural Modelling group process should secure the participation of representatives from each stakeholder roles otherwise the quality of IM outputs might be compromised. This research study managed to secure the participation of 10 out of 25 questionnaire respondents which represented the client, designer, decision maker and actively involved stakeholders as depicted in Table 4-3 below. Although, the IM group size

was within 6 to 12 participants as recommended by Warfield and Cardenas (2002), the participation of more stakeholders could have enhanced the IM discussions.

The interactive management methodology adopted in this research study is only effective if the targeted population is educated, knowledgeable, and have sound experience in the delivery of electrical distribution projects. Therefore, the passively involved stakeholders such as the Department of Energy, Northern Cape Industries and Northern Cape Communities were excluded from the research study.

The questionnaire used for data collection in the research study was unstructured in nature. The questionnaire respondents wasted some time to think about the factors that cause late delivery of electrical distribution projects at Eskom Northern Cape Operating Unit. In order to ensure that responses by the participants were not off the point resulting in poor data value during the idea generation process, the researcher had to illustrate an example of one delay factor and the description.

The selected IM group participants consisted of some individuals who were power motivated, and wanted to outshine everybody in the group. Peterson (2007) suggested that power motivated individuals can affect the outcome of the group discussion negatively. The researcher managed these power motivated individuals meticulously and afforded all group participants to share their opinions which yielded a positive workshop outcome.

5.3 Beyond this Research

The interpretive structural modelling adopted in this research study revealed the hierarchical model illustrating interrelationships between the twenty six identified project delay factors. The ISM model demonstrated the three root causes of project delays in the delivery of electrical distribution projects at Eskom Northern Cape Operating Unit. The ISM model can be used by the decision makers at Eskom Northern Cape Operating Unit to take appropriate steps in addressing the delays experienced in the delivery of electrical distribution projects. Interactive Management methodology can be used to formulate the strategic solution for the identified root causes. Different contextual relationships can be used to structure and propose solutions for the identified root causes. However, addressing the identified root causes is beyond the scope of this dissertation.

5.4 Conclusion

Project delays can result in Eskom distribution to contravene with Electricity Regulation Act 4 of 2006 in terms of supplying South Africans with electricity that is safe, reliable and in a non-discriminatory manner. Eskom distribution strives to comply with Electricity Regulation Act by initiating and implementing strengthening projects, refurbishment (reliability) projects, direct customers, infills projects and electrification projects. The severe delays experienced in the delivery of electrical distribution projects have a negative impact on South African economic growth and population.

This research study adopted interactive management methodology for the identification of delays in electrical distribution projects at Eskom Northern Cape. Using interactive management approach, a total of one hundred and twelve project delay factors were reduced to twenty six significant project delays. The twenty six significant factors were modelled using an Interpretive Structural tool, Concept Star software. The ISM model revealed the three root causes of project delays in the delivery of electrical distribution projects. The ISM model also revealed a circular feedback loop between the identified root causes. This implies that when solving one element in the loop can lessen the impact on other elements in the loop (Nthunya *et al.*, 2017).

The research study revealed that two out of three root causes of delays demonstrated by the output of interactive management process are different from initial votes collected during NGT process. For an example, the root causes “project scheduling not properly done” and “poor planning” were only voted by 2 and 4 out of 10 participants respectively, but ISM model revealed that these elements are the key drivers of delays in electrical distribution projects. This reveals that when participants examine the interrelationships between system elements through IM, they draw a different conclusion.

This research study adopted soft systems approach which emphasizes learning between the participants. The soft systems thinking focuses on identifying the underlying cause of problems and, through the use of computer simulations, evaluating the consequence of responses and other scenarios. The three root causes can be used as critical points for eradicating delays in electrical distribution projects at Eskom Northern Cape Operating Unit.

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7. APPENDICES

7.1 Appendix 1: UCT Research Ethics Approval

Appendix Removed due to visible signature

7.2 Appendix 2: Research Approval by Eskom General Manager

Sent from my Samsung Galaxy smartphone.
-------- Original message --------
From: Klaas Gouws <GouwsK@eskom.co.za>
Date: 26/05/2017 13:56 (GMT+02:00)
To: Bonga Ntshangase <bonga.ntshangase@gmail.com>
Subject: Re: Ethics Clearance for Masters Dissertation

Hi Bonga

Yes your request is granted. Will we be able to get a summary of the findings and possible recommendations?

Regards
Klaas

Sent from my Samsung Galaxy smartphone.

-------- Original message --------
From: Bonga Ntshangase <bonga.ntshangase@gmail.com>
Date: 2017/05/26 13:02 (GMT+02:00)
To: Klaas Gouws <GouwsK@eskom.co.za>
Subject: Fwd: Ethics Clearance for Masters Dissertation

Good day, Mr Gouws

My name is Bonga Ntshangase. I hereby request a permission from you as an Acting General Manager of Eskom NCOU, to conduct a research survey in your operating unit.

The purpose of my research is to identify the delay factors in electrical distribution projects (strengthening, infills, direct customer, refurbishment, and electrification) at Eskom Northern Cape Operating Unit. I worked for Eskom NCOU for approximately four years as a Senior Electrical Design Engineer, and I am familiar with Eskom Code of Ethics.

I have attached the consent form, and questionnaires that will be used to conduct the research survey for your perusal.

Your response regarding the above-mentioned matter will be highly appreciated.

Regards
Bonga Ntshangase

7.3 Appendix 3: Confidentiality and Consent Form

Research Topic: Identifying delay factors in electrical distribution projects at Eskom Northern Cape Operating Unit

Researcher: Bonga Ntshangase

Dear Participant

I am conducting a research study to fulfil academic requirements for Masters of Science degree in Project Management through the University of Cape Town. I am researching on delay factors in electrical distribution projects at Eskom Northern Cape Operating Unit. I would like to invite you to participate in this research survey.

Eskom distribution has a mandate to supply South Africans with electricity that is safe, reliable and in a non-discriminatory manner in accordance with Electricity Regulation Act 4 of 2006. Eskom ensures compliance to Electricity Regulation Act by initiating and implementing strengthening projects, refurbishment (reliability) projects, direct customers, infills projects and electrification projects. Some of these distribution projects experience severe delays which impact South African economic growth and population negatively. The purpose of my research is to identify factors causing delays in electrical distribution projects at Eskom distribution, and to determine interrelationships amongst the identified delay factors using Northern Cape Operating Unit (Kimberley) as a study case.

Please be advised that the information shared in this survey is completely anonymous. Your participation is voluntary, and if you wish to withdraw at any time, you will be able to do so at no detriment to you whatsoever. You are humbly requested to complete the questionnaires, and an interview will be conducted with you to clarify the information collected from the questionnaire. Using interpretive structural modelling, a group discussion will be arranged with respondents to determine interrelationships amongst the identified delay factors. The group will comprise of 6 to 12 selected participants to put forward their opinions as to whether or not the relationship exists between the identified delay factors.

The information gathered from the questionnaires, and interviews will be treated confidentially. The researcher will conduct the survey meticulously, and thoughtfully

in such a manner that there are no risks involved for Eskom Distribution, Northern Cape Operating Unit, Kimberley.

Should you require any information throughout or before the process of completing the questionnaire or during the interview, please feel free to contact the researcher on either 078 861 6686 or bonga.ntshangase@gmail.com.

Name of participant …… Date ……

Signature of participant ……

7.4 Appendix 4: Sample Questionnaires

Research Topic: Identifying delay factors in electrical distribution projects at Eskom

Researcher: Bonga Ntshangase

Please assist the researcher by ticking in the appropriate boxes of the questionnaire.

1. Kindly indicate your current department in Eskom Northern Cape Operating Unit.

☐ Network Engineering & Design	☐ BIPM
☐ Plant Management	☐ Network Services Centre
☐ Operations & Maintenance	☐ Materials Management
☐ Network Planning	☐ Network Optimisation
☐ Project Execution	☐ Customer Services
☐ Electrification Planning	☐ Land Development
☐ Specialised Maintenance & Support	☐ Capital Accounting

2. Please indicate the level in which electrical distribution projects are delayed at Eskom, Northern Cape Operating Unit.

	Very High	High	Moderate	Low
Electrification projects	☐	☐	☐	☐
Strengthening projects	☐	☐	☐	☐
Refurbishment projects	☐	☐	☐	☐
Infills projects	☐	☐	☐	☐
Direct customer projects	☐	☐	☐	☐

3. Electrical distribution projects are delayed at which stage/s of Project Life Cycle Model.

Initiation phase (CRA)	☐
Definition Phase (DRA)	☐
Execution Phase (ERA)	☐
Close Out Phase (FRA	☐
All stages in PLCM	☐

4. Do you think electrical distribution projects are managed appropriately in accordance with project schedule management processes at Eskom Northern Cape Operating Unit?

☐ Yes
☐ No

5. How long have you worked in your department?

☐ < 1 year
☐ 1-3 years
☐ 3-6 years
☐ > 6 year

In your opinion, and based on your experience as an Eskom employee. Kindly list 6 factors which in your perception result in late completion of electrical distribution projects (strengthening, refurbishment, infills, direct customer, and electrification) at Eskom Northern Cape OU, and kindly give a brief description of each factor.

	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1		
2		
3		
4		
5		
6		

7.5 Appendix 5: Completed Questionnaires

QUESTIONNAIRES

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

Researcher: Bonga Ntshangase

Please assist the researcher by ticking in the appropriate boxes of the questionnaire.

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X Network Engineering & Design	☐ BIPM
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☐ Project Execution	☐ Customer Services
☐ Electrification Planning	☐ Land Development
☐ Specialised Maintenance & Support	☐ Capital Accounting

2. Please indicate the level in which electrical distribution projects are delayed at Eskom, Northern Cape Operating Unit.

	Very High	High	Moderate	Low
Electrification projects	☐	x	☐	☐
Strengthening projects	☐	x	☐	☐
Refurbishment projects	☐	☐	x	☐
Infills projects	x	☐	☐	☐
Direct customer projects	☐	☐	x	☐

3. Electrical distribution projects are delayed at which stage/s of Project Life Cycle Model.

Initiation phase (CRA)	x
Definition Phase (DRA)	x
Execution Phase (ERA)	x
Close Out Phase (FRA	x
All stages in PLCM	☐

4. Do you think electrical distribution projects are managed appropriately in accordance with project schedule management processes at Eskom Northern Cape Operating Unit?

☐ Yes

X No

5. How long have you worked in your department?

☐ < 1 year

- ☐ 1-3 years
- ☐ 3-6 years

In your opinion, and based on your experience as an Eskom employee. Kindly list 6 factors which in your perception result in late completion of electrical distribution projects (strengthening, refurbishment, infills, direct customer, and electrification) at Eskom Northern Cape OU, and kindly give a brief description of each factor.

Delay factor		Description of delay factor
	Poor Planning	Inadequate information at CRA stage. No or poor customer information. Tribal issues which delay projects.
1	Infill projects	No capacity approval for projects. Initially data capturing is insufficient PE's need to go and verify information. As built information is not available.
2	Unavailability of wayleaves agreements	Way leave issues are delaying projects. This causes a delay on electrification projects. No Capacity.
3	Poor planning	Many of these projects are initiated without proper investigations and are based on a wish list methodology.
4	Lack of Funding	Currently many projects in Eskom are delayed due to a funding issue. There is also no scheduling taking place of projects in the NCOU.
5	Poor project classification	Completing these self- build projects in the capital environment is delaying the projects. According to me Minor Works is the platform to run them.

QUESTIONNAIRES

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

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	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Unavailability of Surveyor General drawings from municipalities for Electrification projects.	The Design Engineers are then forced to go pick up coordinates for each stands on site which delay detailed design hand over date
2	Lack of resources (Human resources)	Currently in Network Engineering & Design which is responsible for DRA phase of a project life cycle model there is only one Draughts personnel, no civil engineers, No Senior Design Engineers for MV/LV and HV lines
3	Unclear scope definition	Most of refurbishment projects are delayed on execution phase due to overlooked scope of work e.g Implementation plan we often struggle to acquire needed outages during construction which results in project delay
4	Unavailability of material	This is very common in most electrification projects. Sourcing of material not happening in time.
5	Unscheduled project	Creates confusion among team members. Members focus on different priorities.
6	Not following the Project Life Cycle Model	e.g. stakeholder input meetings, Project Scheduling and Construction handover meetings play a major delay in projects.

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Delay factor		Description of delay factor
	Poor Planning	Inadequate information at CRA stage. No or poor customer information. Tribal issues which delay projects.
1	Community Unrest	Communities have a tendency of stopping projects their households are not electrified as part of the project. Communities end-up vandalising the material for the projects, which delays the project drastically.
2	Poor stakeholder engagement	Eskom project managers fail to co-ordinate the stakeholders, which will cause the project to deviate from project objectives.
3	Poor contractor experience	Eskom contractors have constructed projects with a lot of defects. Projects have been found not be accordance with drawings, and specifications.
4	Adherence to policies, and standards	Projects in NCOU have to follow process in terms of work flow. Electrification projects cannot process of the change control forms are not signed by the department of energy. The project cannot be presented to the investment committees.
5	Incorrect design drawings	Contractors are expected to have access to Eskom website to download all standards, and specifications. Contractors end up using outdated drawings due to access issues. Projects are delayed when the conducts re-work in order to conform to the latest standards.
6	Breakage of equipment's	The drills get damaged when drilling rocks on site. This delays the construction of the project.

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Environmental Approvals	The new substations require an environmental impact assessment (EIA) approval. The project should have Tree Cutting Permits if there are tree to be cut. If the line runs across the river, then we as Eskom we need to apply for Water Use Licence Authorization (WULA) of which it takes time to be approved.
2	Wayleave Approvals	Refurbishment and strengthening are delayed because of wayleaves not signed on time. The reason is the land owner (s) does not have any interest in the line that is running in the farm or he/she had issues with Eskom previously and those issues were not resolved. When you want a signature from him/her, he/ she will say solve this issues first. Some land owners wants money from Eskom of which Eskom don't pay any money if the line is 11kv or 22kv because it's not a servitude, it's only a right of way. The right of way is not registered in deeds office. Sometimes the land owners (neighbours) are not in good terms. Sometimes the land owner doesn't know anything about the project, reason for this is because he/she bought the farm and the previous owner didn't notify him/her about the wayleave agreement.
3		
4		
5		
6		

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Late release of funds	Late release of funds delays projects because the work cannot start as per schedule if PO is not issues to a contractor to commence
2	Un-proclaimed areas	From an electrification perspective, project delays due to the fact that GIS spends time trying to create maps for areas where there are no SG plans in place
3	Unavailability of material & Issuing and delivering of wrong material	Late material delivery always causes a delay due to the fact that other things cannot proceed onsite without those material components, it therefore makes the planning to be immaterial e.g one cannot string conductor if poles are not planted. With stores having a tendency of issuing wrong material causes delays because you will find that the place in which material needs to be delivered is far and wrong material is only realised on site that is wrong, so work actually stops cause it must be taken back.
4	Contractors not authorised	Appointment of contractors that are not authorised to do the job in the OU has delayed projects, one will find that that specific contractor is authorized for MV but now is not authorized for LV, then problems arises for he cannot carry on with the work authorization documents are not complete
5	Late introductory to new Contract Bill	Introducing of the new Bill two to three months after the financial year has started and designs have been submitted based on the old bill has caused delays in getting quotations from the contractor and also creates double job from the design perspective
6	Information wrongly inked to a specific town/village	From an infills perspective, Wrong information linkage causes delays for example map of Tshiloane placed under Dockson... when one gets to site can hardly allocate themselves because of such incorrectness information displayed on the map, one find themselves having to have driven ±500km for nothing and have to turn back without doing the verification.

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Poor Communication	It is important for different departments to have channels/platforms of communication and regular meetings. Without communication, other departments/colleagues do not know what is it that the other department requires OR expected of them by others.
2	Lack of training and mentoring	Knowledge is built through formal and informal training. If others that are more knowledgeable do not share their knowledge or do coaching on newer colleagues, then acquiring of skills/knowledge is delayed to newer employees.
3	Environmental approvals	Department of Environmental Affairs is responsible to give Eskom approvals to build new HV lines and Substations. Sometimes these approvals take time. Therefore it is impossible to execute the problem.
4	Lack of knowledge of ACNAC/K2	A lot of colleagues do not know how to use ACNAC/K2. Due to this fact, projects delay due to lack of movements in activities in CRA, DRA, ERA, FRA phases.
5	Lack of Discipline	Lack of discipline can delay the agreed project delivery schedule. This is in two ways, that with which a delay may be cost by an individual doing a task due to complacency. Secondly, due to over-ambitious delivery schedule while in fact individuals involved know the challenges involved however do not want to be realistic. This is to avoid criticism and rather tow the line instead of being realistic. At the end of the day, the target is then not achieved due to this fact. And that then causes frustration to all involved.
6	Financial Constraints	Without funding then departments cannot be fully resourced. NED /LD cannot start with work on the projects as they cannot recover. Execution cannot appoint contractors and construct the asset. So funding is important.

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Delay factor		Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Scope Imprecision	Scope imprecision which needs clarification at execution phase results on major delays because alterations are done on site with contractor on site. Most of the time this results in additional material need to be acquired and cost escalation.
2	Staff Competency level	In the Northern Operating Unit, most of critical positions are filled by new staff with low level of competency or no experience in the project environment.
3	Funding Constraints	Most projects in the Northern Cape Operating Unit get to execution stage without hundred percent funding being allocated to the project. This results in projects being deferred to the following financial years.
4	Communication between Project Members	In the Northern Cape Operating Unit projects teams don't communicate more regularly when involved in the projects. They normally don't have project progress meetings to update all stakeholders involved.
5	Project Risks Identification & Documentation	The project risks are not properly identified and track throughout the project life cycle. Project teams lose track of project risks that were identified at CRA and/ or DRA. The projects risks that are not managed in the project have the tendency of delaying the projects at execution stage.
6	Procurement Process	Eskom procurement contributes significantly to projects delays in Eskom Northern. The process design does not talk to the projects time lines it viewed and managed as an additional and separate work flow. Human competence factor also contribute to the slow procurement process in this regard.

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1		From planning point of view one of the challenges, its increased number of stands on informal settlement during construction of the project that result in community unrest.
2		Communication breakdown between the community members and the local municipality on planned projects.
3		Most contractors that are on the new electrification contract are not authorised to work in our operating unit.
4		Some of the contractors on Panel A are not authorised in the NCOU hence task orders cannot be issued to them.
5		The comity members and taxi association not allowing contractors to transport its employees to local site. They force contractors working in local areas to subcontract some activities.
6		

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Incorrect material	Incorrect material delivered on site, which delays the project time as the material needs to be reordered in order to get the correct material for the project.
2	Incompetence of staff	OU employs new people and they are adequately trained to deliver on the job.
3	Poor Communication	Poor communication between contractors and PC which results on the project expectations not met or compromised.
4	Weather conditions	If there is bad weather conditions that can result to contractors not working.
5	Unforeseen circumstances	For an example, If the contractor was working, discovered that the area is rocky and was unprepared, can cause a delay on a project.
6	Leadership changes	Different leaders with different leadership styles and expectations. This has negative effects on team morale.

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Water use licence approval	Delays in water use licence approval.
2	Design Changes	Design changes will influence schedule.
3	Weather conditions	Can rain for weeks this delays construction.
4	Striking employees	No work will be done for safety of employees.
5	Material lead times	Waiting for material can delay project.
6	EIA approval	Delays in EIA approval.

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2. Please indicate the level in which electrical distribution projects are delayed at Eskom, Northern Cape Operating Unit.

	Very High	High	Moderate	Low
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Strengthening projects	☒	☐	☐	☐
Refurbishment projects	☒	☐	☐	☐
Infills projects	☐	☐	☒	☐
Direct customer projects	☐	☐	☐	☒

3. Electrical distribution projects are delayed at which stage/s of Project Life Cycle Model.

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Definition Phase (DRA)	☒
Execution Phase (ERA)	☐
Close Out Phase (FRA	☐
All stages in PLCM	☐

4. Do you think electrical distribution projects are managed appropriately in accordance with project schedule management processes at Eskom Northern Cape Operating Unit?

☐ Yes
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5. How long have you worked in your department?

☐ < 1 year
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In your opinion, and based on your experience as an Eskom employee. Kindly list 6 factors which in your perception result in late completion of electrical distribution projects (strengthening, refurbishment, infills, direct customer, and electrification) at Eskom Northern Cape OU, and kindly give a brief description of each factor.

	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Planning Resources for Electrification	Planning delays cause delay in Designs causing incorrect costs estimate, causing delays in starting Projects
2	Financial Constraints in Eskom.	Projects get reprioritised and postponed.
3	Lack of Business support / Partners	Absence of Business Partners in the OU delays projects as priority is given to anchor OU's
4	Management of PLCM	PLCM is not effectively implemented
5		
6		

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

Researcher: Bonga Ntshangase

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Designs not Completed on time	designs that are done at the year of execution are causing a delay to the execution of Projects
2	delays in Releasing funds	Time lines from Capital Accounting to release funds is too long
3	ACNAC Activities are linked incorrectly	People names who supposed to capture activities are not linked, K2 Controller has to manually move the projects individually
4	Shortage in Material	Materials shortages from
5	Procument process	Time lines of procurement are too long to complete the tender process Rates too long
6		

Northern Cape Operating Unit

Researcher: Bonga Ntshangase

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Money	Shortage of the money can also delay projects.
2	Schedule	Most of the project are not schedule
3	EIA Aproval	EIA delay projects because it takes too long.
4	Long lead material	Material can also delay project.
5	Additional of scope	Addition of the scope to the existing scope can also delay projects.
6	No access to the software	If person has access to the software and other employees don't have access it also delay project.

QUESTIONNAIRES

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

Researcher: Bonga Ntshangase

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Resource Constraints	-Projects get delayed due to shortage of resources.
2	Lack of funding.	-Projects lack funds in order to be executed. Most projects are not included in the budget.
3	Project Management Processes	-The project managers tend to get involved in the projects at the Definition phase instead of at the Initiation stage.
4	Poor Planning.	-When poor planning is applied at the start it delays the schedule of the project.
5	Scope Changes due to Econonomical Changes.	-Due to the changes, customers are forced to change their initial plans for their projects and opt for cheaper ones.
6	Cost-saving initiatives - Changes of Business Strategies.	-Cost saving tends to compromise quality as engineers are sometimes restricted to go to site

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1	Material purchases e.g Transformers	Long lead materials are only ordered after an EEA form is approved by investment comitte instead of at design stage.
2	Project Resources & overloading.	More resources are needed in engineering design and also project execution Resource end up being overloaded & other projects are parked/delayed
3	Material availability at our stores.	There is always a shortage of material during execution which causes the contractors to wait. This result in delays & delay claims by the contrac
4	Scope	sometime what is designed compared to construction site might be different which leads to design changes and also delays our projects

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Lack of Human Capital	The lack of human capital in Asset creation space contributes alot.
2	Politics	In Electrification projects politics plays major role.
3	Lack of Financial Capital	Eskom has lately implemented budget cuts, which in turn Affects production
4	Processes:	The EIA and environmental projects really appects and delay projects in a big way.
5	The moral of the employees	The employees have not been happy lately largely because of lack of clear career paths.
6	The lack of direction in Asset creation space.	For the past few months there has not been a clear direction in asset creation and what needs to happen.

QUESTIONNAIRES

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

Researcher: Banga Nishangase

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	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	*Design reviews are not adequate	*Engineering does not perform design reviews to minimize design changes.
2	*Poor material procurement process	• Project manager put reservation dates and material → Project managers are not in control.
3	Lack of competent resources	* ~~All~~ All employees are not competent *
4	*Geotech. studies inconclusive	* Rock encountered during construction stage of project.
5	*Lack of competent project managers → promotions	* People are in project management just for position
6	*Eskom processes delays projects	*Eskom processes are very slow in turn delay projects.
⑦ Organisational structures		* Engineering personnel focus on special function.

QUESTIONNAIRES

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

Researcher: Bonga Ntshangase

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	BUDGET CONTRAINTS	CAPEX BUDGET KEEPS ON BEING REDUCED & THAT AFFECTS PROJECT SCHEDULE. SOME PROJECTS DON'T EVEN GET LOST IN THE SYSTEM DUE TO INACTIVITY
2	LACK OF FOLLOWING PROCESS	PLCM TRAINING WAS VERY HIGH-LEVEL & NOT IN DEPTH. THE IMPLIMANTATION THEREOF AS WELL IS LACKLUSTRE
3	LACK OF RESOURCES	THERE IS A LACK OF RESOURCES BOTH HUMAN & EQUIPMENT; AND ALSO EXTERNAL RESOURCES (CONTRACTORS).
4	POLITICS	POLITICS MAINLY AFFECT THE ELECTRIFICATION SPACE. MUNICIPAL FEUDS (ANC V/S EFF VS DA) & PROTEST ACTIONS WHERE MATERIALS GETS DESTROYED
5	REMOTE & VAST AREA	THE N.C PROVINCE IS GEOGRAPHICALLY BIG & THE AREAS ARE REMOTE. HENCE A LOT OF TIME IS SPENT ON TRAVALING
6	SKILL TRANSFER OR SKILL RETAINMENT	THIS ALSO SPEAKS TO LACK OF HUMAN RESOURCES. THE OU IS BATTLING TO RETAIN PEOPLE AS PEOPLE LEAVE DUE TO VARIOUS REASONS (FAMILY, LIFESTYLE, COST OF LIVING, ETC) THUS WHEN SOMEONE VACATES A POST, IT TAKES TIME TO REPLACE THEM OR FOR THE

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	environmental issues (EAI, WULA,TREE CUTTING PERMITS)	The environmental issues such as tree cutting permit. If the line runs across the river then we as eskom we need to apply for river crossing of which it takes time to be approved.
2	Wayleave issues	Refurbishment and strengthening are delayed because of wayleaves not signed on time. The reason is the land owner (s) does not have any interest in the line that is running in the farm or he/she had issues with Eskom previously and those issues were not resolved. When you want a signature from him/her, he/ she will say solve this issues first. Some land owners wants money from Eskom of which eskom don't pay any money if the line is 11kv or 22kv because it's not a servitude, it's only a right of way. The right of way is not registered in deeds office. Sometimes the land owners (neighbours) are not in good terms. Sometimes the land owner doesn't know anything about the project, reason for this is because he/she bought the farm and the previous owner didn't notify him/her about the wayleave agreement.

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	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Late release of funds	Late release of funds delays projects because the work cannot start as per schedule if PO is not issues to a contractor to commence
2	Un-proclaimed areas	From an electrification perspective, project delays due to the fact that GIS spends time trying to create maps for areas where there are no SG plans in place
3	Unavailability of material & Issuing and delivering of wrong material	Late material delivery always causes a delay due to the fact that other things cannot proceed onsite without those material components, it therefore makes the planning to be immaterial e.g one cannot string conductor if poles are not planted. With stores having a tendency of issuing wrong material causes delays because you will find that the place in which material needs to be delivered is far and wrong material is only realised on site that is wrong, so work actually stops cause it must be taken back.
4	Contractors not authorised	Appointment of contractors that are not authorised to do the job in the OU has delayed projects, one will find that that specific contractor is authorized for MV but now is not authorized for LV, then problems arises for he cannot carry on with the work authorization documents are not complete
5	Late introductory to new Contract Bill	Introducing of the new Bill two to three months after the financial year has started and designs have been submitted based on the old bill has caused delays in getting quotations from the contractor and also creates double job from the design perspective
6	Information wrongly inked to a specific town/village	From an infills perspective, Wrong information linkage causes delays for example map of Tshiloane placed under Dockson... when one gets to site can hardly allocate themselves because of such incorrectness information displayed on the map, one find themselves having to have driven ±500km for nothing and have to turn back without doing the verification.

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	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Geo-tech studies that are inconclusive	Delays projects and affects material selection
2	Political riots	Delays the projects completion and results in projects costs escalation
3	Skills shortages	Affect quality of designs results in design during construction

Northern Cape Operating Unit

Researcher: Bonga Ntshangase

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Refurbishment projects	☐	☐	☒	☐
Infills projects	☐	☐	☐	☒
Direct customer projects	☐	☐	☒	☐

3. Electrical distribution projects are delayed at which stage/s of Project Life Cycle Model.

Initiation phase (CRA)	☒
Definition Phase (DRA)	☐
Execution Phase (ERA)	☐
Close Out Phase (FRA	☐
All stages in PLCM	☐

4. Do you think electrical distribution projects are managed appropriately in accordance with project schedule management processes at Eskom Northern Cape Operating Unit?

☐ Yes
☒ No

5. How long have you worked in your department?

☐ < 1 year
☒ 1-3 years
☐ 3-6 years

In your opinion, and based on your experience as an Eskom employee. Kindly list 6 factors which in your perception result in late completion of electrical distribution projects (strengthening, refurbishment, infills, direct customer, and electrification) at Eskom Northern Cape OU, and kindly give a brief description of each factor.

	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Difficult landowners	- Not want to sign the wayleave/option.
2	Passing away of the landowner after signing the option	-This delays the project because we must identify the beneficiary in order to proceed with the registration of servitude
3	Past experience by the landowner by Eskom contractors	- landowner may object the proposed route for power line base of the bad experience on the existing lines.
4	unsurveyed land (unknown)	-is very difficult to get the rightful landowners because the piece of land is not registered
5	Compensation (money) by the landowners	-Now there is lot of IPP projects and they don't compensate landowners based on the valuation. So landowners they expect Eskom to compensate them more money like IPP, and Eskom standard allow us to compensate based of the land value of the property.
6		

QUESTIONNAIRES

Research Topic: Identifying delay factors in electrical distribution projects at Eskom, Northern Cape Operating Unit

Researcher: Bonga Ntshangase

Please assist the researcher by ticking in the appropriate boxes of the questionnaire.

1. Kindly indicate your current department in Eskom Northern Cape Operating Unit.

☐ Network Engineering & Design	☐ BIPM
☐ Plant Management	☐ Network Services Centre
☐ Operations & Maintenance	☐ Materials Management
☐ Network Planning	☐ Network Optimisation
☐ Project Execution	☐ Customer Services
☐ Electrification Planning	☐ Land Development
☐ Specialised Maintenance & Support	☐ Capital Accounting

2. Please indicate the level in which electrical distribution projects are delayed at Eskom, Northern Cape Operating Unit.

	Very High	High	Moderate	Low
Electrification projects	☐	☐	☐	☐
Strengthening projects	☐	☐	☐	☐
Refurbishment projects	☐	☐	☐	☐
Infills projects	☐	☐	☐	☐
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Execution Phase (ERA)	☐
Close Out Phase (FRA	☐
All stages in PLCM	☐

4. Do you think electrical distribution projects are managed appropriately in accordance with project schedule management processes at Eskom Northern Cape Operating Unit?

☐ Yes
☐ No

5. How long have you worked in your department?

☐ < 1 year

☐ 3-6 years
☐ > 6 year

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	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Water use licence approval	Delays in water use licence approval.
2	Design Changes	Design changes will influence schedule.
3	Weather conditions	Can rain for weeks this delays construction.
4	Striking employees	No work will be done for safety of employees.
5	Material lead times	Waiting for material can delay project.
6	EIA approval	Delays in EIA approval.

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	Delay factor	Description of delay factor
	Example Unexpected soil conditions	Rocky soil conditions can result in project delays, when the contractor has to drill the rocks which was overlooked during planning, and design stage. This can also result in project cost escalation.
1	Planning Resources for Electrification	Planning delays cause, delay in Designs causing incorrect costs estimate, causing delays in starting projects
2	Financial Constraints in Eskom.	Projects get reprioritised and postponed.
3	Lack of Business support / Partners	Absence of Business Partners in the OU delays projects as Priority is given to Anchor OU's
4	Management of PLCM	PLCM is not effectively implemented
5		
6		

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Researcher: Bonga Ntshangase

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1	Lack of funding	Projects are not executed due to budgets constrain, that lead to projects being done on ad hoc basis
2	Project Management Processes	Due to project managers being involved at Definition phase, instead of concept phase. This lead to unnecessary project time delays.
3	Poor Planning	Because PM planning is not done it leads to poor planning, it affects the end user quality on results, which, inturn will delay duration of the project
4	Resource Constraints	Lack of resources for example shortage of staff, leads to projects not getting executed in time.
5	Scope change due to Economical changes	Because of economical climate change it leads to customer to deviate from original scope of work to a future time. Or going opt for a cheaper alternative.
6	Cost saving initiatives - change of Business and poor Communication	Unclear communication on how to implement cost saving initiatives, lead to poor quality work from engineers.