UNIVERSITY OF KWAZULU-NATAL

APPLICATION OF SYSTEMS THINKING IN REVIEWING POWER-INFRASTRUCTURE CAPITAL INVESTMENT IN SOUTH AFRICA

by

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DECLARATION

I, **Zothini Nicholas Chili,** declare that

(i) The research reported in this dissertation, except where otherwise indicated, and is my original research.

(ii) This dissertation has not been submitted for any degree or examination at any other university.

(iii) This dissertation does not contain any other person's data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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ABSTRACT

The aim of this study was to investigate how the application of systems thinking can minimize revenue losses in capital power-infrastructure investment in South Africa. The study reviewed the application of existing financial models such as Return on Investments (ROI), Internal Rate of Return (IRR), and Schedule Performance Index (SPI) to multi-years of capital power-infrastructure investments with an intention of introducing new investment evaluation model. In order to achieve the study objective, the researcher had to investigate using the systems approach the challenges regarding development of capital power-infrastructure investments, and apply systems thinking in evaluating the positive impact of timeous payments by debtors. This study was conducted mainly within Eskom comprising 150 engineers that are in the capital power-infrastructure process. Seven of the engineers who are in executive position participated in the qualitative part of the study and 90 engineers participated in the quantitative part of the study. In other words, the sample of the study comprised of 97 engineers involved in capital power-infrastructure investment.

The research employed both quantitative and qualitative mixed method approach. The study found that knowledge management and corporate governance in power utilities of South Africa, including Eskom, is very weak. Furthermore, financial models used such as Internal Rate of Return, Return on Investments, Net Present Value, Level Cost of Energy and Cost of Unserved Energy did not realize the envisaged benefits. Other problems identified by the study included but not limited to multi-packages of contracting instead of single contracting for turnkey solution, lack of understanding the environmental history of where infrastructure was to be constructed, complication caused by procuring services from foreign companies, and lack of proper front- end planning. The participants that were subject matter experts in capital power-infrastructure investments linear regression analysis have proven the consistent relationship between scope liquidity and cost variances and further concurred that current financial models used to assess returns are mostly not realized.

The study recommends the formation of a special governance committee that will ensure that there are front-end planning processes, including the application Complexity Factor, as the way of ensuring financial returns and enable successful delivery of capital power-infrastructure investment. The proposed committee should also advise on the suitability of the service provider in provision of the turnkey solution. The recommended special governance committee should also ensure competency of foreign companies in alignment with Supply Chain Management requirements of South Africa during bid evaluation and adjudicating. The study further recommends a systems model that can be used by power utilities to ensure that initial envisaged benefits are realized.

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CHAPTER 1

INTRODUCTION AND OVERVIEW OF THE STUDY

1.1 INTRODUCTION

This chapter provides introduction and overview of the study. It gives some background information about the study, the problem statement, objectives, questions, aims, significance, and limitations of the study. Further to that, it provides methodology applied to this study and more importantly, it gives an indication where the study was located and conclusions on this study.

1.2 THE BACKGROUND OF THE RESEARCH

This study reviews various energy sources, together with related advantages and disadvantages and compares it; with related energy availability during deployment, revenue income shortfalls from both private and public sector, including municipalities. Moreover, the study reviews capital under investment of government on power utilities to existing grid capital infrastructure for mostly capacity upgrade (strengthening), electrification and refurbishment projects.

It is evident from the findings of Hallowes (2011) that power utilities, more particularly Eskom and municipalities such as EThekwini Electricity, Johannesburg City Power, and Cape Town experienced dynamics in terms of supply and demand. The power demanding market varied from being economic driven before 1994 to include electrification demand post 1994 to 2021 (Slabbert, 2015). This was due to changes in economic trends and political landscape (Moodley, 2015). The apartheid government (before democratic government election on the 27 April 1994) versus democratic government (post-Presidential inauguration in May1994) had various strategic priorities. Democratic government focused on the electricity for all programs including rural areas whilst that was not the priority for apartheid government.

In South Africa, before 1994 and even few years after, power utilities were known to be financially strong. Power utilities in South Africa just like today comprised of Eskom as the main state-owned power supplier and local municipalities of the time. Previously before democratic government election in 1994, power utilities were mainly the centre of economic growth of South Africa because they were capable of withstanding the industrial needs. Furthermore, power utilities had limited safety demand and regulatory compliance requirements.

The demand for electricity before 1994 was slower than todays' because South Africa was experiencing low economic growth due to a number of reasons. Firstly, the townships economy was slower because commercial businesses were concentrated in the towns and the cities. Secondly, there was a very low

electrification in the townships and rural areas as it is the case today. Lastly, there were economic sanctions imposed on South Africa to force South Africa to reform and remove apartheid policies. Despite this, power utilities continued to be financially sustainable.

Contrary to what was happening in South Africa in the past as indicated above, in 2019 township economy of South Africa had grown considerably. Furthermore, a larger portion of South Africa's townships and rural areas are now electrified. Lastly, the removal of sanctions in South Africa and new democratic government's policies have attracted investments to South Africa. All these factors have contributed to the increase in the demand for electricity.

In the early stages of the democratic government of South Africa, the increased economic growth necessitated further power-infrastructure capital investment (Nakumuryango and Inglesi-Lots, 2016). Pollet, Stafell and Adamson (2015) described that this meant that power utilities had to have the strong financial position, meaning sufficient financial resources. It also meant that power utilities had to be structured for the new inclusive socio-economic system in line with the envisaged growth in previously disadvantaged economic areas. Unfortunately, such restructuring did not take place at a requisite level or as envisaged. Yelland (2015) stated that this has caught with the times when power utilities are facing revenue income deficit. Furthermore, he mentioned that such revenue income deficit has weakened power utilities' balance sheets. In addition to this, power utilities continued to face increasing safety regulating and compliance demands such as compliance with environmental greenhouse emission reduction (Africa Check, 2019)

Unlike in the early days of South Africa's democratic government, around the year 2019's the country was experiencing economic growth that was higher than in the past but slower than envisaged. In view of the above, power utilities including Eskom in particular, had to find ways of improving capital infrastructure. Furthermore, power utilities need to have sufficient financial resources to achieve this as a strategic objective.

Eskom, as the South Africa's major power supplier had to confront the urgent need to increase its power-infrastructure capital investment especially in the light of aging existing grid system (Eskom corporate plan, 2016/17 to 2020/21). Walwyn and Brent (2015), stated that the existing grid system does not only need servicing and at times replacement as it is aging, but is overloaded and cannot cope with South Africa's increased demand for electricity. Such strain exerted on the existing grid has resulted in South Africa experiencing load shedding (Yelland, 2015). Blom (2019) stated that Eskom has reluctantly resorted to implementing load shedding as a means of coping with the low reserve margins of below 8%. Yelland (2018) and Blom (2019) have stated that this has resulted in large power users in private and public sectors to reduce energy consumption thus inflicting a huge dent on South Africa's Gross Domestic Product (GDP). This in turn has increased the prospects of an even higher

unemployment rate in South Africa. This necessitates construction of a mix of different power stations such as hydroelectric power stations, new thermal stations, interconnection substations, and future renewables.

It is the common knowledge, that the need for maintenance of the existing grid coupled with the need to construct new power stations and sub stations requires Eskom to look at its financial resources and its balance sheet with focus on its debtors' book. It further requires Eskom, as the major power supplier, to assess its related manner to the National Electricity Regulator of South Africa, which is the one tasked with regulating South Africa's energy price increases. This is particularly important because challenges faced by Eskom, as well as general global trends, have seen an increase in independent power producers (IPP's) thus decreasing Eskom's revenues.

The decrease in revenue income impacts directly to reserves of financial resources. Power utilities of South Africa have to consider other factors when making decision relating to infrastructure capital investments. It is the public knowledge that such factors amongst other things include modernization of power utility's operations and globalization, failure to enforce revenue income, governance, centralized coal resources, coal availability and cost of coal as a major ingredient in South Africa's power supply that is just a few to mention. Furthermore, Eskom requires to investigate the possibilities of using renewable energy and other forms of energy mix.

The researcher's distant view that has led to this study that, systemic thinking relating to financial stabilities of South African power utilities requires an integrated approach. In short, it requires Eskom as a major power supplier to use a holistic approach in deciding how to go about its power-infrastructure capital investment. This holistic approach is referred to as system's thinking. There will be detailed discussion related to system's thinking in the next chapter but for the purposes of this chapter, an example is used to provide an insight of what it means. Assume that Eskom's power-infrastructure capital investment is likened to a human body, then for it to be planned and implemented successfully, can be likened with what the human body needs for it to function properly. The human body has different parts or systems as is the case with the proposed power-infrastructure capital investment strategy. The systems of the human body such as the nervous system, the urinary system, the digestive and so forth all are important for the proper functioning of the human body. Likewise, in the case of the power-infrastructure capital investment strategy components such as affordable availability of coal resources, proper relations with the National Electricity Regulator of South Africa, healthy balance sheet and other related factors are all important for it to work as envisaged. If any component or part of the digestive systems or components of the human does not function properly, then the likelihood is that the human body would not perform at its full capacity. Similarly, if any of the components that form part of the power-infrastructure capital investment are not considered the likelihood is that the power-infrastructure capital investment is not likely to succeed.

This study aims to identify elements that are crucial in the formulation and implementation of a successful capital power-infrastructure investment strategy and explain how they can be combined through systems thing to help South Africa solve energy supply problems.

1.3 THE PROBLEM STATEMENT

There is a great demand for capital power-infrastructure investment (Hadebe, Hansa, Ndlhovu and Kibido, 2018). Statistics of South Africa (2017) reported that *R203 billion in 2012 to R284 billion in 2016; an average rise of 8,7% per year".* However, there are significant inefficiencies observed such as estimating the required capital budget (Pollet, Stafell and Adamson, 2015), revenue income and resource levelling, investment life cycles (Yelland, 2015), and non-existence of stakeholders' performance agreements (Zidane, Johansen and Hald (2015), approved capital budget and improper feasibility study to determine the anticipated investment returns (Moloi, 2018).

Kaseke and Hosking (2013) explained that this has led to supply inadequacies whilst the proposals for supply reforms has failed to provide electricity security solutions. The Sub-Saharan Africa (SSA) with 80% access to electricity, has 634 million households without access to electricity and with 433 million people in extreme poverty (Schoch and Lakner, 2020), has got power capacity of 80GW which is equivalent to that of Korean republic alone (Eberhard, Gratwick, Morella and Antmann, 2016).

South Africa, the high-risk investment country (Investopedia, 2019) with 8 million without electricity access, has 91% access to electricity (Eberhard et al. 2016) failed to withstand its economic demand for 40 years (Pollet et al. (2015). The under-frequency load shedding in South Africa has become the chronic reality (Eberhard and Shkaratan, 2012), with 67 Independent Power Producers (IPPs), 4.3GW of $14.4 billion (Eberhard, Gratwick, Morella and Antmann, 2016). South African power utilities have to have adequate power capacity to grow the sustainable economy. This study focuses on investigating the causes of this problem leading to insufficient investments and lack of revenue income.

1.4 AIM OF THE STUDY

The main aim of this study was to investigate how the application of systems thinking can minimize losses in capital power-infrastructure investment in South Africa. In this, the study will review the application of existing financial models such as Return on Investments (ROI), Internal Rate of Return (IRR) and Schedule Performance Index (SPI), to multi-years capital investments with an intention of introducing new investment evaluation model.

1.5 OBJECTIVES OF THE STUDY

- To investigate using the approach of systems thinking, the challenges regarding development of power-infrastructure capital investments.
- To apply systems thinking in evaluating the positive impact of timeous payments by debtors on power capital investment opportunities in South Africa.
- To use stakeholder analysis to view the extent of investment opportunities lost due to costs escalations.
- To formulate systemic model for the evaluation of long-term power-infrastructure capital investment in South Africa.
- To determine how long-lead goods procurement and contracting of foreign skills have on projects.

1.6 THE RESEARCH QUESTIONS

- Using the systems thinking, what are the challenges regarding development of power-infrastructure capital investments in South Africa?
- How can systems thinking be applied in evaluating the positive impact of timeous payments by debtors on capital power-infrastructure investments in South Africa?
- How can stakeholder analysis be used to view the extent of investment opportunities lost due to costs escalations?
- What is the systemic model formulated to evaluate the long-term power-infrastructure investment in South Africa?
- How does the procurement of long-lead goods and contracting of foreign skills impact on projects?

1.7 THE CONTRIBUTION OF THE STUDY

- The study findings and recommendations will contribute to the body of academic knowledge in capital power-Infrastructure investments in South Africa. There is no evidence that suggests that there are published journals focusing specifically on the use of systems thinking in capital power-infrastructure investment within power utilities and Eskom in particular. This research report will contribute towards closing that gap.
- This study will challenge the application of financial models such as Return on Investments (ROI), Internal rate of Return (IRR), Schedule Performance Indicators (SPI), and Performance

Indexes in multi-years of capital power-infrastructure investments within South African power utilities and Eskom in particular.

1.8 LIMITATION OF THE STUDY

- Budget constraints for travelling to areas like Cape Town, Mpumalanga, Northern Cape, Eastern Cape and international conferences on renewable energy technologies.
- Time to complete the study was limited to academic period; therefore, the study could not be delayed incorporating the new renewable energy regulatory framework and policies that the Department of Energy in South Africa was still busy developing.
- The study is not considerate of other global regulating authorities such as NERSA in the case of South Africa.
- The researcher would have liked to incorporate the Integrated Resource Plan (IRP2019), which the researcher had hoped would be available before the finalization of the project, unfortunately its publication delayed.

1.9 THE METHODOLOGY EMPLOYED IN THE STUDY

The study employed a mixed methodology, meaning the combination of qualitative and quantitative method. The discussion of research methodology employed will be in detail in Chapter 4. The quantitative analysis was further supported by conducting the regression analysis which is discussed in Chapter 6. There was consideration of other methodologies in relation to the study. The mixed method was the most appropriate in addressing global complex problems influenced by social, economic and political causalities.

1.10 LOCATION OF THE STUDY

For the qualitative part of the study, the participants were in Johannesburg and Cape Town. These were the Eskom executives involved in capital power-infrastructure investment and one external consultant dealing with cross-border capital infrastructure investments for utilities. For the quantitative part of the study, questionnaires were sent to the participants who were engineers in capital power-infrastructure investments whilst they were attending the annual project management meeting.

1.11 CONCLUSION

This chapter presented challenges currently faced by South African power utilities that has led to revenue income deficit and under-expenditure shortfalls. In this Chapter, the supply and demand for power-infrastructure was explained that it varies between what was demanded pre-democratic government that was ushered in 1994 and that of democratic dispensation. The chapter presented that in past power utilities known to be financially strong with strong balance sheet. Further to that the chapter highlighted in both pre-democratic government of 1994 and until 2019, power utilities continue to be the centre of economic growth. The chapter highlighted the ripple effect to the South African economy when power utilities are facing financially challenges.

The chapter further provided the aims of objectives of the study as well as the research questions that were to be answered based on collected data. In addition to this, the chapter indicates the particular contribution of this research project. Furthermore, limitations encountered during the research project are indicated in this chapter.

The following chapter, chapter 2, presents a theoretical framework of systems thinking. It first recognizes various theories and their presents each theory's limitations in reviewing challenges related capital power-infrastructure investments. Chapter 2 further demonstrates the relevance of systems thinking in reviewing power-infrastructure investment challenges including global issues and domestic consumers' perception related cross subsidization.

CHAPTER 2

SYSTEMS THINKING THEORETICAL FRAMEWORK

2.1 INTRODUCTION

The aim of this chapter is to present a theoretical framework for understanding how systems thinking will work, when reviewing capital power-infrastructure investments. The study will introduce conceptual understanding of systems thinking. At first, the study presents recognized world problems solving theories available and their application before selecting systems thinking.

It will be outside the scope of this research to engage in an argument of who is the founder of Systems thinking between Checkland and Senge. In this chapter, other theories will be reviewed together with systems thinking as defined by Senge (1990). Systems thinking is recognized as the system that is having the holistic approach in resolving world social complex matters. This has been supported by Akthar, Awan, Naveed and Ismail (2018), stating that systems thinking is a holistic approach in resolving complex world social matters. It is because of that consideration that systems thinking was viewed as appropriate in solving South Africa's challenges relating to capital power-infrastructure investment.

2.2 THE WORLD PROMINENT PROBLEM-SOLVING THEORIES

Oxman (2017) stated that there are more than three thinking theories that are in existence, but some are not relevant for solving holistic worldwide complex problems. In the following section, different theories are presented as reviewed in literature. Their relevance is further demonstrated with their limitations in resolving world complex power-infrastructure capital investment challenges. The three theories that will be addressed are critical thinking, creative thinking and active open-minded thinking.

2.2.1 Critical thinking

Doyle (2019) described critical thinking as the psychometric skill that certain people have to analyze information and make objective decisions. Abrami, Bernard, Borokhovski, Persson, Waddington, Wade (2015) and Dwyer (2017) stated that this is the process that is mostly applied in analyzing information, which includes deducing the flow of information and relationships. Walsh (2015) supported this narrative but further explained that critical thinking includes conceptualization of the information in relation to the required standards. Furthermore, Kim, Sharma, Land and Furlong (2013) supported by McCormick, Clark and Raines (2015), stated that critical thinking has the ability to separate researched

information from assumptions by analyzing the source of information for its credibility. Erstad (2018) stated that there are five stages of critical thinking namely:

- Analytical,
- Evaluation,
- Ensuring information objectivity and curiosity,
- Relevance of the information
- Conclusiveness

These processes of evaluation are based on certain eventualities and predictions of what could happen next (Walsh, 2015). Cargas, Williams and Rosenberg (2017) stated that the last process includes making predictions based on conceived knowledge.

The study viewed critical thinking as not appropriate for solving world complex capital power-infrastructure investment challenges. The study deemed this as more relevant for thinking purpose or to analyzing patterns, which could be the census where population growth projection requires estimation. The relevance of this theory is in fact finding such as in criminal investigations, data presentations and so on. This is where separation of facts versus fiction deemed pertinent. The study, using literature review, found that critical thinking has limitations in worldwide cultural or societal matters. Therefore, the application framework for critical thinking would not be relevant in reviewing holistic social complex challenges related to power-infrastructure capital investments. Critical thinking will further not be suitable to be utilized to review poor municipalities that are failing to collect their own revenue to pay Eskom from their own consumers and foreign countries.

2.2.2 Creative thinking

Baer (2014) described creative thinking as the technique of assessing various presentations or data in order to derive divergent causality from perceptions or norms, in order to create solutions to the problem. In other words, creative thinking is a process of generating ideas in order to solve non-algorithmic problem (Montag-Smit and Maertz, 2017). Candi, Jae, Makarem and Mohan (2017) stated that data collection for creative thinking involves gathering information from various sources and pay more attention to what is factual. Montag-Smit and Maetz (2017) further stated that the information that is being presented has to be consistent with what is intended to be achieved.

Jankowska and Karwowski (2018) conducted the study pertaining how children entering the school from various background can be creative in problem solving and participative learnership. In this study, there were children coming from families with high socio-economic status (SES) background versus those that are coming from less socio-economic status background. Initially, Montag-Smit and Maertz

(2017) and Candi et al. (2017) had similar findings with Jankowska and Karwowski (2018) that children coming from families with high SES had better creativity. Their finding was that the creative thinking was environmental base instead of being family bound.

The study considered creative thinking, but it was not appropriate to this study as it had limitations to holistic views, as it does not have a reputation of resolving world complex matters but helps in conceptualization of divergent thinking. Its appropriateness in the multi-causality and systemic implication leading towards the failure of power utilities in power-infrastructure capital investment had limitations. However, the study concluded that the relevance of creative thinking cannot be totally discarded in driving towards the solution of capital power-infrastructure investment in South Africa.

2.2.3 Active open-minded thinking

Baron (2018) stated that Active Open-Minded Thinking (AOT) was developed by Baron in 1993. When Baron (2018) developed it, he described AOT as the theory that assesses rational disposition of the complex problem. He then used an example such as why people always vote for people that are not competent to lead into government. Stenhouse et al., (2018) described AOT in a similar way to that of Barons (2018). They all stated that regardless of how much people know the truth about anything such as global warming, poor administration about their politicians, high bank rates compared to others and so forth; change against the known truth requires a change in the mindset. Stenhouse et al., (2018) further stated that most of these change requirements can be measurable and be addressed such as in the case of global warming but change requires people to adapt to the new requirement.

Dasgupta and Ehrlich (2013) and Mellers, Stone, Atanasov, Rohrbaugh, Metz, Ungar and Tetlock (2015), all supported that AOT is used to assess how human minds think. Baron (2018) further stated that it is clearer that AOT requires standard of measurement pertaining how people think. The study did not deem this theory relevant, as its psychometric properties has never been thoroughly reported, the literature revealed that AOT required certain scales as input analysis, which were outside this research study. Whether companies, municipalities and neighboring countries have money to pay for electricity services rendered or not, is what this study must be able to determine.

Summarily, the study has considered the above three problem solving thinking theories. The relevance of critical, creative and active open-minded thinking as presented in section 2.2.1 to 2.2.3 above, had limitations in addressing capital power-infrastructure investment, therefore deemed inappropriate for solving the world holistic complex problems. In the following section 2.3, the study presents conceptual understanding of systems thinking. It continues to manifest its relevance in various global studies presented in this chapter.

2.3 CONCEPTUAL UNDERSTANDING OF SYSTEMS THINKING

Senge (1990) described systems thinking as the technique that analyses the interconnected and the direction of influence for the world complex situations and create an in depth understanding of the root cause and its drivers.

Lane, Munro and Hesemann (2016) citing Checkland (1999) stated that in developing systems thinking diagram, there are micro-processes or sub-systems that are defined as environments. In other words, as Akhtar et al., (2018) stated that it is through systems thinking that the world complex problems can be holistically viewed through the diagram and be understood. They further review Akthar et al. (2018) together with Behl and Ferreira (2014) and Senge and Sterman (1992), confirmed the narrative raised by Senge (1990) that systems thinking is powerful and able to solve holistic complex worldwide challenge and to derive the solution. Cabrera, Cabrera, Powers, Solin, and Kushner, (2018) reviewed systems as a system that is applicable in all learning organizations for design perspective of identifying causal factors and influences Abbas, Shaheen, Elhoseny, Singh and Alkhambashi (2018), for individual parts in the and change. It is for that reason, Williams, Kennedy, Philipp and Whiteman (2017) managed to provide the narrative that systems thinking can be applied in management research, emphatic to the point that the application of systems thinking changes organizations for better. Salehi and Yaghtin (2015) conducted the research related to organizational transformational matters, on that research there was synergy of Action Research (AR) with systems thinking and derivation of impactful solution.

Taştan and Davoudi (2015) presented tranquility convergence of systems thinking and its relevance towards making changes. These changes could be on world holistic complex matters or social behavior (Erkutlu and Chafra, 2015). Molderez and Fonseca (2018) stated that the causal-factors for power utilities' failure to achieve rapid development in power-infrastructure capital investment. Filho, Nunhes, Barbosa, De Campos and De Oliveira (2018) supporting Mitchell (2015) stated that boundaries of the entire systems thinking are autonomous presented in the form of circles. Taştan and Davoudi (2015) stated that in order to be able solve world complex problems, individuals within any organizations need to learn in order to grow. Erkutlu and Chafra (2015) supported, and stated that any organization need to have individuals that are empowered for the change but must possess the following skills:

Personal Mastery: According to Senge (1993), this is the skill of being self-cautious of capabilities. Moreover, to that, Lane et al., (2016)'s beliefs is that people need to embark on self-developmental journey and paradigm shift from the existing purpose, vision, belief, commitment and knowing oneself.

Shared Vision: The learning organization should always be part of systems thinking and have to have ability to share how the future of the organization will be like (Khana, Rehman, Virani

and Vadnagarwala, 2016)**.** Williams et al. (2017) stated that futurist view of the organization should be such that the current operating system should be integrated but as part of the futuristic view and that view must be known by everyone within the organization.

Mental Model: In 2003, Stacey, now anchored by the literature of Ehrlich (2017) described mental model as an interpretation of certain thoughts about how the world or certain things work. This requires acceptance through an understanding of both cognitive and behaviorist theories to deduce causalities, deliberation and conclusions regarding financial instabilities world power utilities (Janežič, Dimovski and Hodošček, 2018) of how stakeholders and world power utilities. There are many studies conducted in the power utilities but most of the world power utilities are still struggling to maximize financial sustainability. Uhl-Bien and Arena (2017) on organizational dynamics and complexity in organizational leadership necessitated that new questions on the previous discoveries and described as double loop learning.

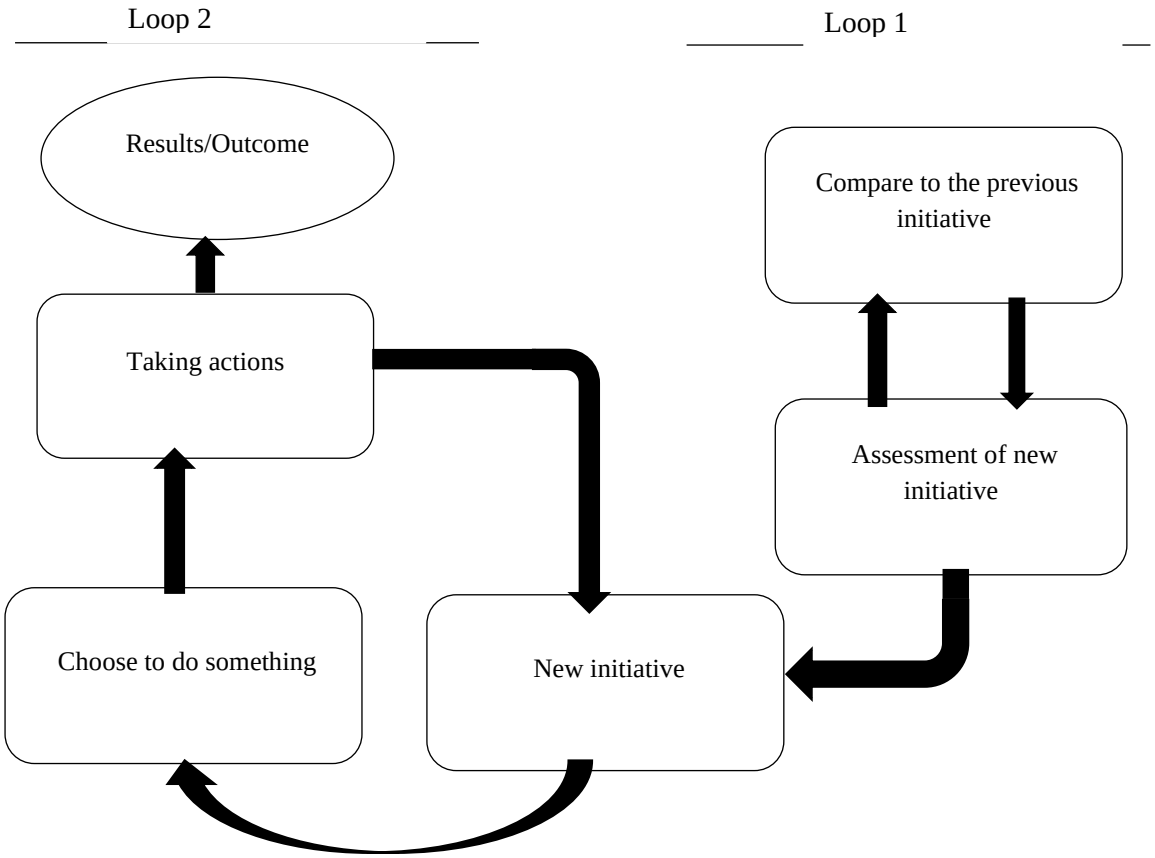
The study conducted by Cabrera et al. (2018) supported by Midgley, Johnson and Chichirau (2018) have attested that systems thinking as the holistic view, is inclusive of learning organization. Shao, Feng and Hub (2017) contextualized systems thinking as relevant for transformational leadership. Phaneuf, Boudrias, Rousseau and Brunell (2016) supported similar view by stating that transformational leadership prepares toward the change in order uplift self or team or organizations through learning and change.

Team learning is organizational learning, where an individual will impart knowledge, and organizational vision to other team members (Nguyen, Mia, Winata and Chong, 2017), supported by Davies, Swilling and Wlokas (2018), stated that transformational leadership include extending yourself outside the existing organizational cultures and norms in order to arrive at organizational vision.

Chen and Agrawal (2018) supporting Senge (1993) emphasized the great need for organizational learning so that people will work towards the same goal in the organization. According to Davis, Challenger, Jayewardene and Clegg (2014), supported by Ngunyen et al. (2017) and Chen and Agrawal (2018), in the case of capital power-infrastructure investments in power utilities, teams within the power utilities and the society will have to learn a new approach towards driving effectiveness. Bouwmans, Runhaar, Wesselink and Mulder (2017) expressed that organizational transformation and decision making should always be through team participation. Learning organization forms an integral part of systems thinking (Behl and Ferreira, 2014). Mulder (2018) expressed that the society have to be able to provide influence related to power utility and the people are inside the organization have to work on interconnections and patterns together. Bouwmans, et al., (2017) explained this, in a form of double

loop learning, as the requirement to transform power utilities. Behl and Ferreira (2014), further explains that the achievement of transformation requires that both the society and people inside the organization to learn, that's the double loop learning as depicted in Figure 2.1 below.

Figure 2.1: Double Loop learning in organization



Source: Lozano, Ceulemans and Seater (2015)

In Figure 2.1 above, the new initiative is derived for the achievement of organizational change. In the figure 2.1, the learning organization the business must identify the need for business review, develop new strategy, review business performance in that new derived operating strategy, and compare it to how the business previously operated. The learning organization technique assist in assessing if the new initiative is required to be developed further and be compared with the previous initiative, refer to Loop 1).

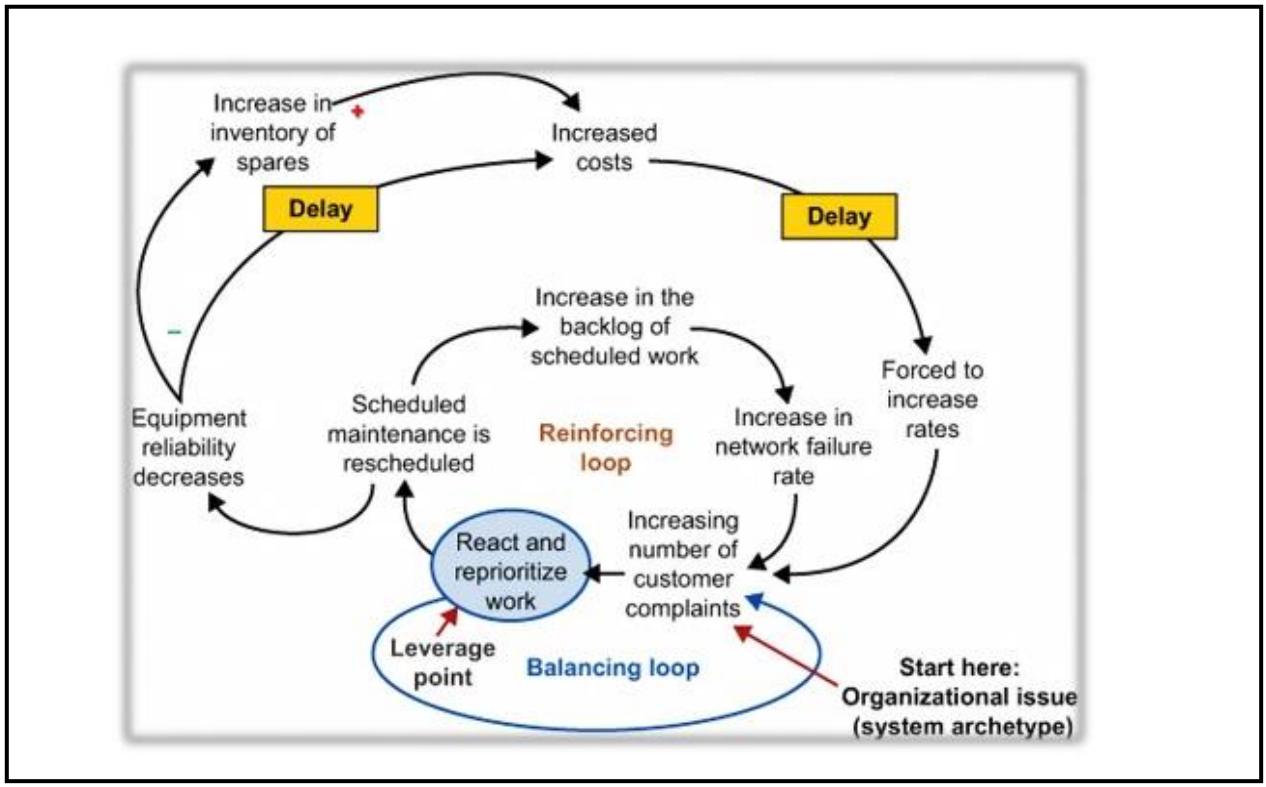
The decision will have to be made if the new initiative must be implemented or not. If the new initiative must be implemented, by choosing to do something, then the move is towards the execution of the new initiative by taking actions. The action again will have to be reviewed if it is still related to the initial intended objectives. Assuming that, when reviewing, it is discovered that there is a variation, it means

that corrective actions (choose to do something) have to be implemented. Then review the results or outcome.

As Saadat and Saadat (2016) stated, in the case of power-infrastructure capital investment, similar modelling can be applied as part of organizational learning. Matthies and Coners (2018) stated that there is a lot of double loop learning applicable in capital investment projects. Akhtar et al. (2018) on their study in Malaysia and Parkistan concluded that there is a positive relationship between organizational learning and systems thinking.

The theoretical framework regarding how systems thinking works is demonstrated in the following

Figure 2.2: The concept of systems thinking



Source: Cabrera, Cabrera, Powers, Solin and Kushner, 2018

Referring to Figure 2.2, there are arrows indicating the direction of influences (Cabrera et al., 2018). Cristobal (2017) defined that as causal factors. In other words, when referring to figure 2.2, the backlog of doing maintenance will certainly increase the network failure rate (Al-hazim, Salem and Ahmad, 2017).

In Figure 2.2, environments or patterns resulted in an application of systems thinking. This business was faced by increasing number of customer complaints. The organization had to make the decision whether to attend to these complaints or carry on working as if customers did not complain.

According to Salling and Leleur (2015), in many instances, organizations had to make decisions. In Figure 2.2, the organization had to look at business impact between reprioritizing work whilst there were increasing number of customer complaints. In reviewing Amin and Bernell (2018), as number of complaints kept on increasing, the business had to make decision whether to rescheduling equipment maintenance closer than initially planned or not.

Puisa, Lin, Bolbot and Vassalos (2018) defined causal factors in systems thinking by stating that this is the environment that causes change to another environment. In Figure 2.2, rescheduling the maintenance closer was caused by the decrease in equipment reliability. According to Ahmad, Bazlamit and Ayoush (2017), they stated for any business finding itself where they have high frequency of rescheduling maintenance and unreliable equipment, such business had to further look at what to do regarding costs that they charge to customers. Do they have to increase it or delay it? Cristobal (2017) believed that in order to reduce customer complaints, the maintenance of equipment required spares. The business inventory had spares to address to customer complaints. The business had to look at possible delaying cost increases or force increases.

Then the business looks if the replacement of faulty equipment with new spares does reduce customer complaints. On the other side, the business reviewed the impact of delaying scheduled maintenance and realized that it will lead to maintenance backlog and an increase in network failure. That was going to further increase customer complaints. In closing on this theoretical framework, Cabrera et al. (2018) explain that systems thinking diagram must be able to provide a feedback loop for the holistic understanding of the problem, structures, people, patterns and processes for organization to operate healthy.

In providing the comprehensive understanding of systems thinking, two examples where systems thinking applied to solve problems are presented in the next section.

2.3.1 Reviewing the example of where systems thinking was applied

In this section, two conceptual case studies done in two countries at different times in order to demonstrate an understanding of systems thinking. The purpose of conducting the two studies in Malaysia and Pakistan was to lay the foundational cognitivism related to the application of systems thinking.

2.3.1.1 Summary on the Case Study of banking employees in Malaysia and Pakistan, the effectiveness of systems thinking in banking sector

Akthar et al. (2018) conducted the comparative analysis of banking employees in Malaysian and Pakistan banks. Both these countries had the average of 56 banks each (Malaysia 56 and Pakistan 55), governed through strict regulations. Department of Statistics and Government of Malaysia (DOSM, 2018) and Minister of Finance (MOF) in Pakistan presented empirical data representing that both these countries had high growth rate of 5.5% and 5.71% respectively and labour force employment of 60% and 54% respectively (MOF, 2018). These are both Islamic countries that are in Asia, meaning that the environment of operation will almost be predictable to be the same, unlike if the other country was in developing country with unstable economic growth.,

The conclusion of the study was that Malaysian banks had better performance compared to those in Pakistan. In applying the systems thinking, it is imperative to review what could be the causes that could be related to this?

In Malaysia, bank employees had better access to universities compared to those in Pakistan. In other words, there was high level of education including higher developmental programs in Malaysia that started in 2017 compared to Pakistan. United Nations Educational Scientific and Cultural Organizations (UNESCO) brought these developmental programs to both Malaysia and Pakistan (Akthar et al. (2018). In Malaysia, 26% of the bank employees attended UNESCO programs compared to Pakistan (10%). This resulted in Malaysia having higher literacy rate compared to Pakistan and different unemployment rates among these countries. Malaysia with 3.4% and Pakistan with 5.9% of unemployment rates. The vast difference was more on religious, culturalism and number of languages spoken in each country for both these countries. Malaysia was more diverse with Islamic religion dominance of 60.4% whilst Pakistan had Islamic dominance of 97% (MOF, 2017).

Instruments such as education, level of unemployment, banks performance, diversity and other considerations were used for testing effectiveness of systems thinking versus societal changes in Malaysia and Pakistan. Akthar et al. (2018) further stated that the research instrument of this study had various dimensions of testing application of systems thinking.

Islam, Khan and Bhukari (2016) stated that in any broader organization knowledge and human development, the holistic approach towards problem solving creates results visible to the entire world. Khunsoonthornkit and Panjakajornsak (2018) and Smith, Rama and Helms (2018) stated that it is for that reason self-development within the organization is imperative in order to understand the organization better. It further has worldwide benefits, instead of benefiting knowledge of the organizational.

According to Zoogah, Noe and Shenkar (2015), the application of critical thinking, including the interconnectedness of how the organization operates and variations of mental modelling, assist in learning organization. Chahal and Bakshi (2015) stated that in the Malaysian and Pakistan study, the attitude of employees in learning from the previous mistakes, were among tests viewed pertinent. The attitude of the employees in both countries was good, the results were however different for the same instrument used.

Akthar et al. (2018) arrived at the conclusion that systems thinking is the requirement for modern banking era and it influences individuals in an organization to be exploratory, open-minded and have better knowledge of how systems within their organization work. They further concluded that regardless of how modern the technology it uses, the bank performance can also be improved by other factors such as age of employees, gender balance, the level of education, the quality of experience the employees have, the cultural diversity, quality of leadership and understanding of how systems operate. This is the holistic view that systems thinking was aimed to achieve.

2.3.1.2 Summary on the Case Study: Assessing if systems thinking improves perception of patients and culture safety

Tetuan, Ohm, Kinzie, McMaster and Mosier (2017) conducted the study with various medical Professors and Doctors using systems thinking in Kansas City hospitals. In this study, the problem was that there were adverse patients' events that were as the result of medicine administration errors. On this study, Tetuan et al. (2017) further stated that the educational program of systems thinking was conducted in Kansa City hospitals for the period of the year with the aim of improving patient's safety.

The method of conducting the study was such that all nurses were invited to participate in the systems thinking pre-intervention data collection and the post systems thinking intervention data collection conducted. Historically, as Behl and Ferreira (2014) stated, globally patients' safety highlighted some key pertinent factors identified using systems thinking, such as characters, training and skills development, traits, attitude, working environment, exhaustion and fatigue.

This was deemed to be among contributions towards total elimination of medical errors. Surprisingly, the use of barcode in medicine never reduced incidents although it was anticipated. What was important to mention was that medicine related events compromised patient's safety. Tetuan et al. (2017) supported by Swift (2017) continued stating that patients' safety related to inaccurate medication was higher before the systems thinking training was conducted to nurses-. As Rigobello, Carvalho, Guerreiro, Motta, Atila and Gimenes (2017) and Guinea, Andersen, Reid-Searl, Levett-Jones, Dwyer, Heaton, Flenady, Applegarth and Bickell (2018) had conducted studies related to nurses and administration of medicine in various countries. The difference was that in hospitals such as Kansas

City, where nurses were trained of systems thinking, there was an improved performance compared to various hospitals in various countries where nurses were not trained on systems thinking.

The conclusion was that when nurses are trained taking into consideration the organizational impact or looking at how the system works, they started to understand the organization future vision better. The application of systems thinking made nurses to understand that medical administration meant patient's safety, good hospital reputation, business growth, sustainable revenue income and more job creation.

In the following section, the study introduces the relevance of systems thinking in reviewing capital power-infrastructure investments.

2.4 CONCLUSION

In this chapter, the theoretical framework of systems thinking was introduced and followed by three theories namely critical thinking, creative thinking and Active Open Minded Thinking (AOT). Summarily, critical thinking is the psychometric skill of analysing information and make objective decision by separating facts from assumptions. Creative thinking, as the thinking skill that involves gathering information, analysing various presentations, assessing and generating ideas to develop the solution to the problem. Active Open Minded (AOT) is the skill that requires the change of mind, accepting the existing fact or reality in order to pursue the new approach. In describing the AOT, the chapter made two examples, the first was why people continue voting for incompetent people into government. Secondly, it was that people are the solution in addressing challenges of global warming.

Further to that, this chapter presented systems thinking and its relevance in solving short and long complex world challenges. The chapter presented systems thinking and its difference from above three mentioned thinking theories. The explanation was given that systems thinking looks at the holistic worldwide complexities to derive to the solution and changes the approach towards organizational changes. In the chapter, it illustrated that the application of systems thinking in capital power-infrastructure investments, meaning that people will have to learn new things. The effectiveness of systems thinking was done through two case studies reviewed to test the applicability of systems thinking. The first was the Malaysian and Pakistan study; both these countries had 56 banks that governed under strict regulations, with high growth rate of 5.5% for Malaysia and 5.71% for Pakistan, the labor force of employment between 60% for Malaysia and 54% for Pakistan. The university enrolment was (26%) for Malaysia compared to Pakistan (10%) with the unemployment rate of 3.4% for Malaysia and Pakistan for 5.9%. Malaysia had 60% diversity on religion compared to Pakistan, 97%.

The second study was on the safety of patients; where nurses received training to understand the holistic impact of issuing the correct medication, ensure proper administration and handling of patients. The

relevance of systems thinking in all objectives was tested and it became apparent that all the objectives aligned into their objectives through systems thinking. The power shortage presentation in SADC and SAPP highlighted that in addressing capital power-infrastructural challenges, matters including global politics, skills competency, bilateral trading relations and stakeholders' acceptance of the proposal.

In the following Chapter 3, the focus will be on the literature review regarding how global power utilities able to sustain themselves compared to 187 licensed national power utilities. Chapter 3 will also review IPPs related costs, the GDP growth versus other indices such as inflation, electricity costs, demand growth, the tax implication and the need for electricity not only in South Africa but also in SADC.

CHAPTER 3

LITERATURE REVIEW

3.1 INTRODUCTION

The main aim of this chapter is to review the literature to determine how some other power utilities manage to realize revenue-income benefits from their capital power-infrastructure investments. The information gathered from literature reviews and data collected from both qualitative and quantitative research in Chapter 5, will be combined to develop systems thinking which will be discussed in Chapter 6 of this study.

The literature review in this study comparatively reviews South African power utilities such as Eskom, Johannesburg City Power, EThekwini Electricity, Cape Town Electricity, Msunduzi Electricity and to power utilities from developed countries such as in Europeans Union, USA and China. The study further reviews power utilities from developing states such as Malaysia, Pakistan and Bangladesh.

The comparison will include modernization versus revenue collection, governance, approaches toward strategic investment, structural design, ability to manage stakeholders' expectations and all other related strategies leading to financial sustainability. The chapter further presents signals leading to liquidity crisis currently faced by Eskom but not disregarding other 187 licensed electricity distributors approved in terms of Electricity Regulation Act (Act 4 of 2006). The study applies comparative analysis between developed and developing countries to review the impact of revenue income or losses through various renewable energy technologies, power import, sales projections, foreign and domestic debts, globalization, the impact of over-sizing the power utility, stakeholders' performance and economic related matters.

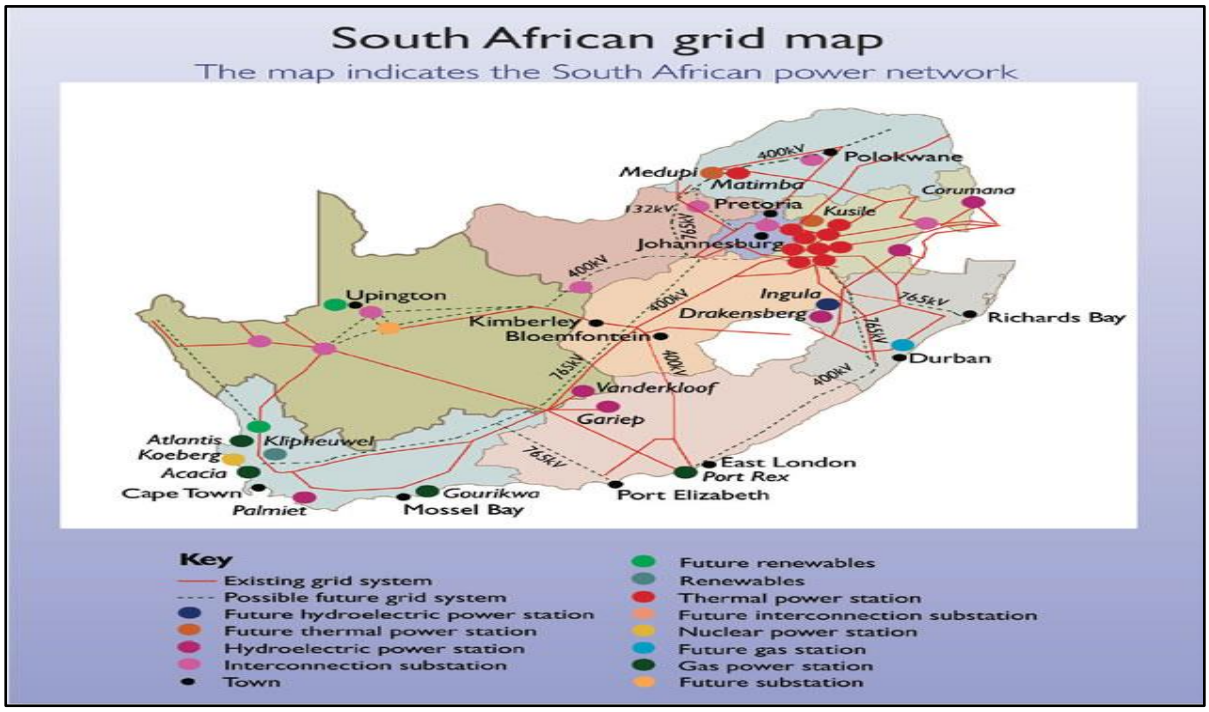
The study starts by presenting the summary of South Africa power utility, Eskom, in section 3.2, but proceed to present its transformational changes in section 3.3 and further compares Eskom to global power utilities in section 3.4. The study also presents the literature review in section 3.5 on how other global power utilities are able to sustain themselves financially, which is different to South African power utilities.

3.2 THE BASIC UNDERSTANDING OF ESKOM AND ITS CAPITAL POWER-INFRASTRUCTURE INVESTMENT

The history of Eskom as detailed from www.eskom.co.za indicates that the establishment of Eskom was in 1923 under then South African Electricity act of 1922 and has its Head-Office in Johannesburg, Megawatt Park. The website continues to state that it was named as Electricity Supply Commission (ESCOM) and it also became prominent within South Africa and the world with its Afrikaans name Elektrisiteitsvoorsieningskommissie (EVKOM). These two acronyms reviewed in 1986 and the name Eskom was registered and branded with a strong view to represent Southern African Power Pool (Eskom, 2018). Eskom is the seven largest power utility in the world and mostly generating power from coal-fired power stations in Mpumalanga province, which has abundance of coal (Monyei and Adewumi, 2017).

The following Figure 3.1 presents the existing Eskom infrastructure only within the borders of South Africa (Eskom financial results, 2012). The conceptual understanding of the word grid in Figure 3.1 is that it means geographical location of where power lines traverses. This word "grid" will be used repeatedly in this study.

Figure 3.1: Eskom South African Grid Map, as on the 10 May 2015



Source: Eskom, 2015

Evident from Figure 3.1, the grid map consists of multi levels of voltage power lines traversing starting from Mpumalanga province. Looking at the map above, there are dots indicating various technologies of power generations such that hydropower stations indicated in black dots and nuclear power stations in yellow dots on the bottom left of the map. Eskom corporate plan published for the financial year ending in 2017, indicated that Eskom has power lines supplying 1 034 mines, 83 136 agricultural, 2 773 industrial, 50 613 commercial, 5 338 723 residential, 508 rail, 804 municipalities including six metropolitan municipalities who in turn supply in their jurisdictions. It continues stating that Eskom supplies 11 international customers. The abundance of coal and hydropower in South Africa makes Eskom power generation to be dominated by coal (Eskom, 2018). It is only Koeberg in Cape Town, which is the nuclear power station.

As stated earlier that focusing on Eskom does not mean disregarding other power utilities. The literature revealed other South Africa's 187 licensed electricity distributors are experiencing financial problems with the maintenance backlog estimated at approximately R38.6 billion with the continuous growing rate of R3.377 billion a year (Yelland, 2017).

Magubane (2018) stated that Eskom is having many structural related issues, which are similar to those experienced by municipalities (Baleni, 2018). All licensed electricity distributors in South Africa receive regulation for tariff increases by the National Electricity Regulator of South Africa (NERSA), established in terms of National Energy Regulation Act of 2004 (NERSA, 2018). The democratic election of 1994 has made Eskom and all other State Owned Entities (SOEs) to go through various strategic changes of reviving mothballed power stations and distribute electricity to that previously never had (Monyei and Adewumi, 2017).

3.3 TRANSFORMATION OF ESKOM AND RESTRUCTURING OF DISTRIBUTION SERVICES

The history of Eskom has not been different from all other state-owned companies in South Africa such as South African Airways (SAA) and South African Broadcasting Commission (SABC), Transnet and others (Hadebe, 2000). The management was dominantly white and laborers being mostly black African people (Writer, 2017). The changes in these state-owned utilities required implementation of racial and gender equity South African policies.

After 1994 first democratic elections, Eskom restructured to reflect corporate governance principles (Eskom Conversion Act, 13 of 2001). This meant that Eskom was required to account through its Board of directors regarding Public Finance Management Act (PFMA) and ensure provision of the strategic direction and leadership, ethics and policy development and implementation in terms of Code of

Corporate Practices and Conduct contained in the King Report on Corporate Governance for South Africa 2002 (King II Report).

Eskom has evolved and improved on its corporate governance compliances in line with then latest versions of King II and III. This included accountability of fiscal grants from other government departments such as for executing the mandate of electrifying both rural and urban households and expansion of power capacity to withstand economic growth (Mabuza, 2018). The capital investment portfolio expatiated and required the capital investment process to be well developed and proper governing in line with King IV.

3.3.1 The mandate of Eskom

Eskom's mandate is to provide electricity in an efficient and sustainable manner, including its generation, transmission, and distribution and sales. Eskom is a critical and strategic contributor to the South African government's goal of security of electricity supply in the country as well as economic growth and prosperity (Eskom, 2015)

3.3.2 Vision

Sustainable power for a better future (Eskom, 2015)

3.3.3 Mission

To provide sustainable electricity solutions to grow the economy and improve the quality of life of the people in South Africa and the region (Eskom, 2015). This is the synopsis about Eskom, it is not the intention of this study to deviate from investigating about possible challenges leading to capital power-infrastructure investments but giving the high-level understanding was paramount. In the next section, literature focuses on how the world is viewing capital power-infrastructure investment.

3.4 THE ANALYSIS OF THE WORLD POWER UTILITIES COMPARED TO SOUTH AFRICA

The World Nuclear Association (2018) reported the world's population to reach 9 billion by 2040. World Nuclear Association (2018) supported by World Energy Outlook (2018) stating that there will

be electricity demand increase by at least 48% by 2040. This has increased global investments in power infrastructural development such that on the 10 July 2018, World Bank reported on the 2017 global investment portfolio of USD $ 93.3 billion, there were 305 projects. It continued stating that 95% of those global electricity projects are still active to address power infrastructural challenges.

It is imperative to mention that on further research, the number of worldwide projects by World Bank differed in capital investment values and quantities when reviewing the literature in comparison to the Private Partnership Investment (PPI), 2017 database. This was insignificant to this study, as it was not the focus of the research. The difference was that the World Bank reported to have 3686 world projects from 1993 to 2017, energy infrastructure projects continued to dominate by 56% (USD $51.9 billion) of total investment (World Bank, 2017). It would be outside the scope of this study to dwell on why World Bank had different reports, but it was sufficient to know that the power sector dominated the capital investment.

The global challenge in capital power-infrastructure investments and economic growth is that there is uncertainty in cost to completion and schedule to completion (Gorus and Aydin, 2019). Makovsek (2014) supported by Kazadi, Lievens and Mahr (2016), stated it is logical that costs escalations are preventing the disadvantaged people an opportunity to have quicker access to electricity, and that the additional costs paid could had been saved for the establishment of new infrastructure in the area where there is no electricity. CSIR (2017) supported by Carter-Brown (2017) stating that whilst there is more than 1 billion people living without electricity in the world, 600 million are in Africa.

International Energy Agency (2015) reported along the same figures, stating that 18% of people (one in five) do not have access to electricity with Africa and Asia having the highest number of people living without electricity. Jim (2018), the NUMSA-Secretary General, published through Eskom media stated that the investment for global electricity generation requirement estimates is USD $11.5 trillion by 2050. Eikeland (2015) on his research stated the challenge the world is facing is lack of innovation, as there is sufficient solar energy that can meet the global energy demand.

McKensey and Company (2018) stated that the global power utilities' challenge is the realization of returns on investments and include proper assurance that priority investment relates to the priority returns. Ansar, Flyvbjerg, Budzierand and Lunn (2016) argued that some of the global infrastructure investments are initiated with assumptions to have positive contribution to economic growth. Eikeland (2015) stated some of the infrastructure investments initiatives do not influence economic growth or sustainable jobs.

Eikeland (2015) made an example of the British tunnel that left the British economy sinking and the second example is that of Great Belt tunnel of Denmark and Copenhagen that had 80 000 engineers. The completeness of both these projects never realized return on investments (Eikeland, 2015). Kruger (2017) argued against Ansar et al., (2016) implying that there is a direct relationship between infrastructure investment and economic growth, such that Kruger (2017)'s empirical analysis found that a month delay in signing Independent Power Producers (IPPs) by all stakeholders could lead to R12 Trillion revenue income losses by 2020.

In all mega-infrastructure investments, stakeholders' corporation including signing the contracts on time is amongst the challenges faced by power utilities globally. In addition, it is even worst for cross border investments. Gatzert and Kosub (2016) studied European Union (EU), and they stated that EU had a vision 2020 project that demanded 20% more on infrastructure investments due to stakeholders' disagreements leading to project delays. Li and Youngho (2015) stated that between China and India they faced similar challenges but in order to withstand the demand, the cross borderline between India and China with the budget of US5.9 billion rand had to be built.

The critical success factors included early development of policies and procedures pertaining to the stakeholders' agreement (Nevin, 2016). The estimations that developments of capital power-infrastructure will be completed on schedule and on cost, when executing the cross border projects is too risky due to tedious stakeholders expectations (Makovsek, 2014), risk of insurance (Gatzert & Kosub, 2016) and conditions related to Power Purchasing Agreements (Li & Youngho, 2015). However, in the European Union (EU) cross border investments, the difference was that they were successful in stakeholders' co-operative participation by developing policies and regulatory framework. Further to that, there was an insurance and diversification strategies developed for sustainable energy solutions (Gatzert & Kosub, 2016). In this, they engaged people as groups but also as individuals and thereafter they developed the laboratory that modelled the management of stakeholders' interests, expectations and benefits towards the energy development (Castanho, Loures, Fernandez and Pozo 2018).

Arai, Naito and Ono (2018) stated that the failure of financial sustainability of power utilities is similar as the weakening of the pillar structure supporting the roof of the house, as it is the serious point of concern and weakening of economic development. The study conducted by Ono and Uchidi (2018) found that the inability of power utilities to sustain themselves financially have detrimental effect in generations to come. Ueshina (2018) stated that power utility' revenue income challenges leads to poverty, high tax burden to those dependent on electricity for survival and business. Llzetzki (2018) stated that this would mean an increase in GDP, which does not translate to job creation, as it may mean that South Africa is using international companies instead of local companies to address power

challenges. In other words, this could mean that South African power utilities are incurring expenses in foreign currencies (Stevanović, Vujičić and Gajić, 2018).

3.5 WHY GLOBALLY POWER UTILITIES HAVE SELF-SUSTAINING CHALLENGES

Pollet et al., (2015) conducted the study in Asia, Europe and North America on behalf of McKinsey and Company where they stated that the performance of power utilities has always been volatile with the return of 1% starting from 2007 to 2017. The global demand in electricity infrastructure investment is such that China, Asia, USA, European Union, India and Africa are going to be the most global capital power-infrastructure demanding regions by 2025 demanding USD $7.2 Trillion (Mckinsey and Company, 2018, citing International Energy Agency, 2018).

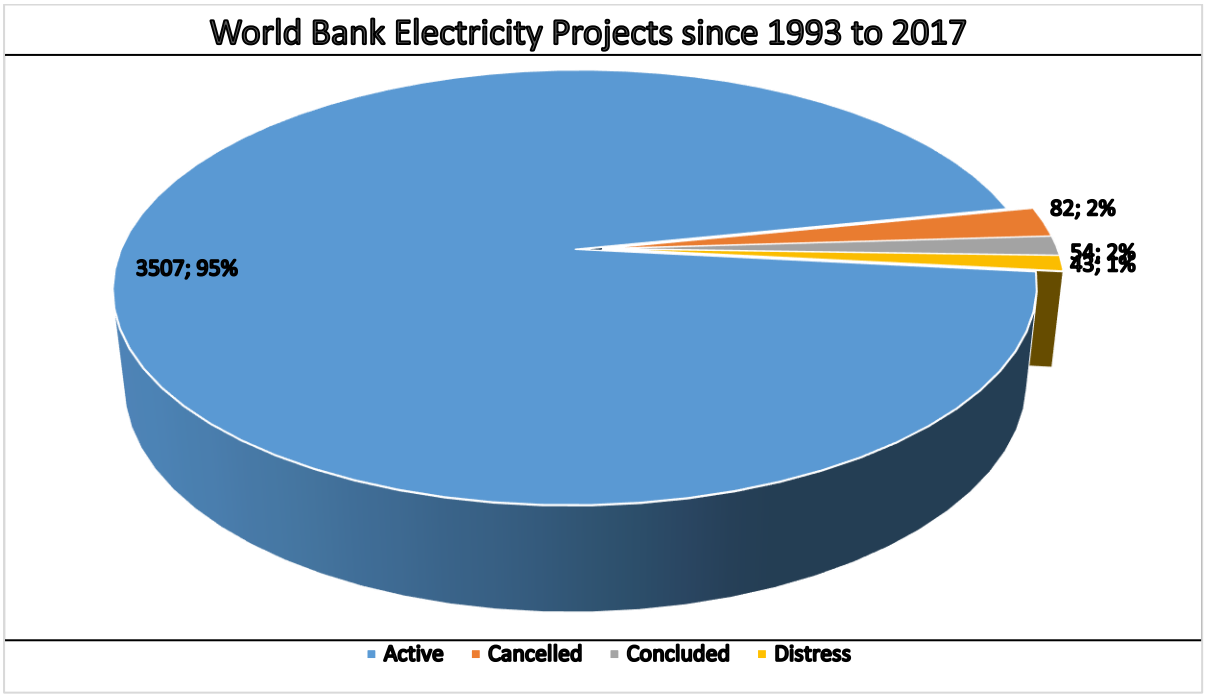
The literature from various sources presented indicators that signifies that the power utility is likely to have financial bankruptcy such as the following:

- The regulatory policies aimed at curbing price increases in distribution section of power utility whilst generation section incurs unregulated costs, such as coal in the case of South Africa (Minnaar, Visser and Crafford, 2017).
- Bhorat and Tarp (2016) specified another causality as an increase in electricity demand whist there is limited investment for capacity upgrade to meet the demand. This leads to increase in maintenance backlog. For example, the study conducted by Aklin, Cheng, and Urperlainen (2015) found that the maintenance plans even in the global approach of using renewable solution would be the requirement to ensure energy security.
- Increasing imports of electricity (Eskom, 2018).
- Larsen, Van Ackere and Osorio (2018) stated the variations in domestic demand versus international demand, with the increase in domestic demand compromising international supply.
- The size of the company, if it is too big, resources output becomes less than their potential production capacity (Larsen at al. (2018).
- Globalization such as investing in the latest engineering technology including renewable energy technologies that are of global standard, are spending money instead of generating revenue income (Eskom, 2016).
- Ineffective management of power losses during transmission, illegal connection, meter tempering and non-payment mostly large power users (Eskom, 2018).

- Yelland (2015) stated policy makers that are not vigilant and lack innovation of the company restructuring always lead the company to the "too big" status that may lead it to collapse (supporting Larsen et al. (2018))

The statement raised by Pollet et al. (2015) that South Africa has been unable meet its domestic energy demand for more than 40 years, inspired the study to review the global capital-infrastructure investment portfolio performance in order to determine if energy problems are only domestic or global. On the literature review, the World Bank (2017) reported that 95% of world capital investments starting from 1993 to 2017 are for power projects and are still active or others in continuous pursuance; others are actively fulfilling the repayment conditions of Power Purchasing Agreement. Figure 3.2 below demonstrates the investment portfolio performance of World Bank in electricity infrastructure.

Figure 3.2: World Bank PPI Annual Report, 2017



Source: World Bank (2017): PPI annual report 2017 accessed on the 16 August 2018

In the above Figure 3.2, 95% (3507) of the world electricity projects were still in active management on the project dashboard. Active projects are unclosed projects because of either an incomplete Engineering, Construction, Procurement and Management (EPCM) process or repayment in terms Shareholder or Power Purchasing Agreements (PPA). It is only 2% concluded, 2% cancelled and 1% on distress. Distressed projects are projects that are outside the values of what could have been expected.

Mostly these projects become distress because of contractual or governance mismanagement. Eikeland (2015) supported by Figure 3.2 above, in his edition of the international newspaper called "The Guardian" stating that there is no world energy shortage. He continued stating that 2 minutes of sunlight energy is sufficient to fuel cars, light, heat buildings, and cater for economic needs for the year. The World Bank's 95% active projects are demonstrating technical challenges and lack of innovation in addressing shortages (Eikeland, 2015).

In this section, the study reviewed literature on global power utilities and compare them with power utilities in South Africa (Tsai, Chang and Chang, 2016). In the world, development of renewable energy, independent power producers have become the new trend of capital power-infrastructure investment (Nakumuryango & Inglesi-Lots, 2016). The gas power plants in Northern Asia and UK are as aging as coal-fired power plants in South Africa built in 1960 and 1970s (World Nuclear Association, 2018).

3.5.1 Regulation of retail prices whilst wholesale price increases

Eskom in South Africa has reported that the coal cost rises at 19% per annum versus 10% industry norm (Eskom, 2016/2017 to 2020/2021 corporate plan). The price of coal is unregulated in the generation section of power sector due to global demand (Ateba & Prinsloo, 2019). On the study related to rise and fall of power utilities, Kenny, Cronje, Moloi and Dimant (2015) stated that this means that mines could inflate coal costs beyond industry norms, without discount factors and possible economies of scale. On the retailer's side (transmission and distribution), NERSA regulates costs or tariffs for electricity prices through Multi-Years Price Determination (MYPD) and Reconciliatory Clearing Accounts (RCA). In reviewing the historical Eskom applications to NERSA versus approvals from year 1999/2000 to 2017/2018, it was only in the year 2012/2013 where NERSA approved tariff increase as applied for by Eskom. In the year 2008/2009. Eskom applied twice for tariff increases but both these applications were approved for less tariff increases than what was applied for.

Yelland (2015) raised concerns regarding the regulatory framework that it is inexplicable for renewable energy. This regulation meant that purchasing Independent Power Producers (IPPs) at R2.02/kwh and sell it for 80c/kwh (export.gov, 2017). It further meant poor business trading conditions when there is excess generated power (Ntusi, 2017. Moolman (2017) stated that the cost for renewable energy is 25c/kwh for developed countries such as Mexico and Chile compared to 80c/kwh for South Africa. In 2016, Eskom refused to sign the IPP, as they indicated that they have lost R9 billion from IPPs (Kruger, 2017).

The literature review on the World Economic Outlook (2018) revealed that in the year 2011, South Africa's costs for Solar Concentrated Photovoltaic (CSP) energy was at R3.65/kwh and wind being

R1.51/kwh and the declined in cost to R0.62/kwh for solar and R0.82/kwh for wind in 2016/2017. Mexico, Chile and Abu Dhabi were relatively paying R0.49/kwh, 0.41/kwh and 0.34/kwh respectively for solar and wind. (Kåberger, 2018). Alfred (2018) stated that in South Africa, companies are winning bids for developing solar CSP at R2.02/kwh (Mabuza, 2018), which is 800% more than what was Mexico, Chile and Abu Dhabi are getting. Mabuza (2018) continued stating that the need for renewable energy in South Africa is inevitable due to requirements for the reduction of CO_2 emissions and replacement of aging power plants.

3.5.2 Increase in demand versus limited investments

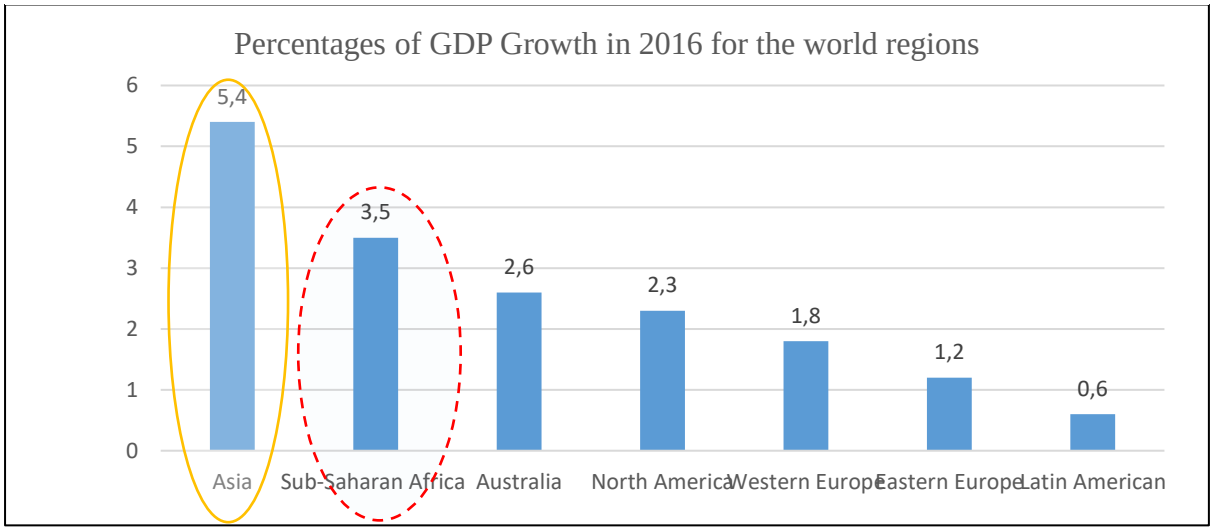
As stated in section 3.4 above, there is an increasing world electricity demand but very low capital investment in electricity sector for developing economies including South Africa (Baleni, 2018). It was further stated that there are 1 billion people without access to electricity in the world of which more than 60% is living in Africa. Minnaar et al. (2017) stated that electricity supply has become the social service instead of becoming the key commodity for economic growth. Electricity is not international declared as the critical commodity (Larsen et al. 2018).

In some of the developing countries such as South Africa, investments in electricity becomes the secondary priority, as importation is the cheaper option. Bruno et al. (2018) studied the impact of importation and its budgetary implications on developing power utilities. For example, in Eskom (2018), the import budget plan for the year 2015 was to spend R380M on electricity import but actually spent R3, 679 billion. In 2016, the budget plan was for R93M, but the actual expenditure was R3,660 billion and in 2017, the budget was for R399M and the actual expenditure was R2.681 billion. These imports were as the results of South African increased power demand. Historically import power has been sourced from Mozambique through Cahora Bassa power line. The findings of McKinsey and Company, (2017), is that most of the developing countries, power utilities meet their demand through power importation.

In South Africa for the FY15-FY17, the actual variation from decision taken was 868% for FY15, 3835% variation for FY16 and 571% for FY17. These was due to repetitive implementation of various stages of load shedding in the country due to domestic shortage of quality of coal falling under Operational Expenditure (OPEX) account. This money should have circulated inside power utilities and minimize pursuing foreign debts. The growth rate of South African economy had attracted foreign investors for business development (Statssa, 2016) and universal electrification program that tapped unto untapped market (Matlawe & Setlhoho, 2013). There was a growing electricity demand that led to power shortages experienced starting in 2007 (Bruno, et al., 2015).

The published World Energy Outlook (WEO) (2018), presented the electricity consumption-growth rate since 1990 to 2017 as being the fastest growing commodity due to electrification in Asia and Sub-Saharan Africa as indicated in Figure 3.3 below. It continued stating that United State of America (USA) and United Kingdom (UK) experienced reduction in power consumption for two-consecutive years due to energy efficiency programs. Further to that, it stated that electricity consumption remained stable in the European Union. This global trend as reported on New Energy Outlook (2018) made by United States of America is such that the renewable energy in regional demand will be 87% for Europe, 75% for India, 62% for China and 55% for US. The expectation is that the electricity generated from coal will decline from 38% in 2017 to 11% in 2050 (New Energy Outlook, 2018), to be referred as (Neo, 2018).

Figure 3.3: Regional percentages of growth of Gross Domestic Products (GDP)

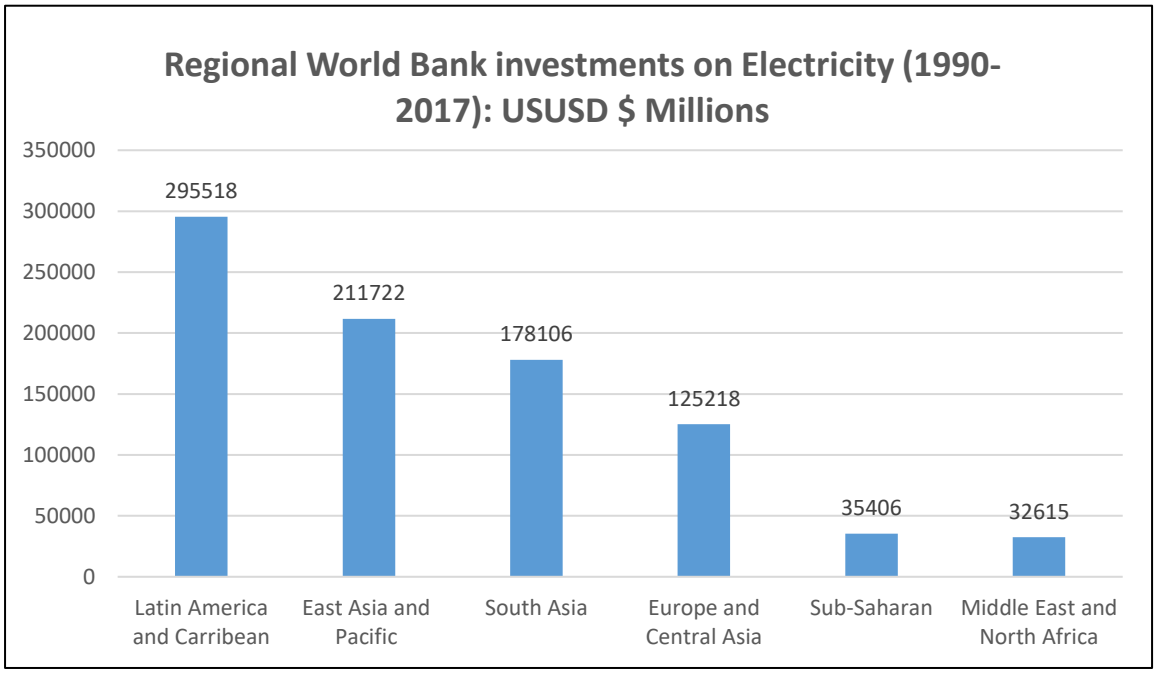


Source: World Bank Annual Report, 2015

In Figure 3.3, the percentage growth of GDP for Asia (5.4%) and 46 listed Sub-Saharan African countries growing by 3.5% as indicated with yellow solid lines and Sub-Saharan Africa indicated with red dotted lines. These yellow and red lines are highlighting countries. It could had been any color. In Chapter 1 Section 1.3, the problem statement presented challenges in the Sub-Saharan Africa. In Figure 3.4, it is visible that in 2016, Sub-Saharan Africa had higher GDP compared to Latin American. When it comes to capital power-infrastructure investments, the inverse becomes the reality. The study analyzed World Bank investments per regions using Figure 3.3 above and Figure 3.4 below. In Figure 3.3, it is evident that Sub-Saharan Africa has the second highest GDP growth of 3.5% compared to other regions such as Latin American and Caribbean, whilst Asian and European countries had higher GDPs. In contrary to the GDP growth rate, when looking at Figure 3.4 below, Sub Saharan Africa has been

receiving second-lowest investment from World Bank. The Sub-Saharan Africa has been receiving the global second lowest World Bank investment for the period of 1990 to 2017 (Refer and compare on Figure 3.3 and Figure 3.4).

Figure 3.4: World Bank investment portfolio per regions since 1990-2017



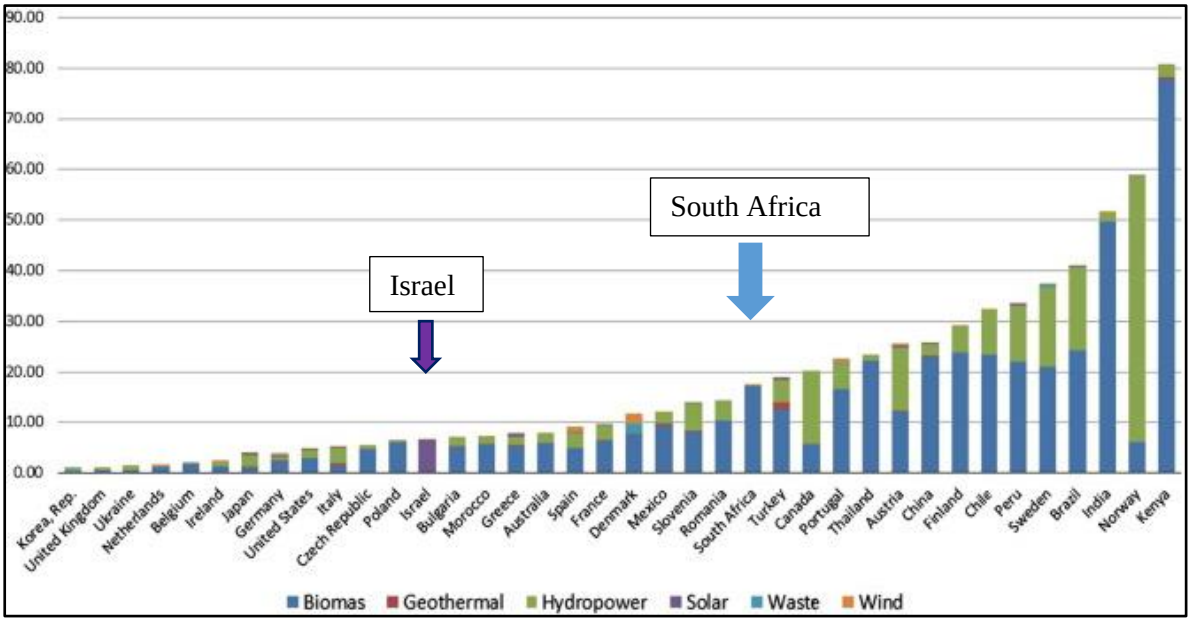
Source: World Bank, 2017 analyzing regional investments on electricity

It was an interesting discovery that Sub-Saharan region had the second lowest investment of USD $ 35 billion as indicated in Figure 3.4 above. In the section that deals with Sub-Saharan region, this research will review into the causality of this degree of this regional investment.

Neo (2018) stated that China electricity consumptions grew by 5.9% since 2014 due to industrial growth. It further continued stating that there is an increased growth rate in power consumption experienced in Canada, Japan, India, Indonesia, Italy, Poland, Turkey, Germany, Spain and South Korea since 2013. Tsai et al. (2016) and Bhattacharya et al. (2016) sees this as the global environmental risk in terms of CO_2 emissions and stated that in order to continue meeting de-carbonizing requirements, the application of 50 by 50 has to be the global strategy (meaning 50% of the world's energy to come from solar and wind energy by 2050).

Bhattacharya, Reddy, Ozturk and Bhattacharya (2016) in their study on the world renewable energy stated that in 2002, the consumption power energy was 18%. Duan and Chen (2018) who conducted the study for 2013 stated that this consumption reached 19.1% of global final energy consumption. International Energy Agency (IEA), (2018) cited Bhattacharya et al. (2016) stating that the renewable energy consumption would reach 39% by 2050 and reducing CO_2 by 50%. International Energy Agency (2018) stated that Africa, Asia and Latin America has been the recent focus for development of renewable energy infrastructure as presented in the following Figure 3.5 below.

Figure 3.5: The global non-fossil energy consumption per technology per country



Source: International Energy Agency, 2018

Evident from Figure 3.5 it is visible that most of the African countries are still dependent on biomass, which is wood, cow-dung and mud for energy. South Africa as indicated and labeled is mostly dependent on Biomass as part of what is regarded as clean energy that does not contributed to CO2 emissions. According to World Energy Outlook (2018), South Africa is mostly dependent on coal and hydropower stations used for peaking. Referring to Figure 3.5, South Africa still has a lot of Biomass energy compared to Canada but lesser compared to India and Kenya. Israel as indicated in Figure 3.5 is mostly producing its energy from solar.

Ntusi (2018) stated that there are challenges pertaining to wind and solar in the energy space, the first being their volatile availability and secondly the storability. Morison (2018) supported by Cilliers (2018) stated that in Europe, wind power has the largest installed capacity (25%) and is the world-leading continent in wind power installation; however, it is experiencing long durations of power failures when there is no wind or load shedding when wind currencies are weak. The Total Cost of

Wind Power Plant ownership from World Bank (2018) conducted in countries with most wind power plants is

Cost = FCR x ICC +AOC
Where FCR is the Fixed Charge Rate, ICC is the Initial Capital Cost and AOC, is Annual Operating Cost.

In 2017, the Global Wind Energy Council cited by Chen, Wang and Stelson (2018) stated that the world had the installed capacity of 539.58 GW. Wind has its own complexities; power production is through wind currents that turns the wind turbines in order to produce power (Ntusi, 24 August 2018). However, Morison (2018) explained the challenge with wind power that Britain went 9 days without wind power. On those 9 days, wind generation capacity was 4.3%, which rendered UK consumers vulnerable to darkness. There is a strong belief that wind and solar are volatile for power supply security, as they are naturally self-driven and self-controlling resources (Ntusi 2018). In Figure 3.5 above, Denmark and Spain are visible to have wind power whilst South Africa is visible to have both solar and wind energy (World Energy Outlook, 2018).

Hoffmann (2019) stated that if the sun does not shine for consecutive days, the power strength becomes inadequate to meet the demand. New Energy Outlook (2018) stated that investing in such unreliable or volatile technologies has been capital intensive but there is a decline in solar PV and wind investment costs, as it is the expectation that by 2050 cost reduction will be in the region of 71% and 58% respectively.

In 2050, investing in wind and solar technologies will have cost competitive and justifiable benefits such as reducing environmental greenhouse emissions in comparison to coal-fired power plants (Zhang, Wang, Xie, Kong, Jin, Hu and Xi, 2018). Vares, Häkkinen, Ketomäki, Shemeikka and Jung (2019) concurred with Irvin Jim (2018) on their renewable energy studies and impact on Greenhouse Gas (GHG) emission was that the shift from coal-powered fired power stations to renewable energy technologies was going to have detrimental impact on world coal-fired power stations job securities. Dostál and Ladányi (2018) stated that another challenge for solar and wind was its energy storability. Olabi (2017) stated that batteries are currently the technology used to store renewable energy but are expensive.

The estimate of solar PV and wind energy cost reduction by 2050 is driven by the assumption that electric vehicles will reduce reliance on batteries (New Energy Outlook, 2018). This is because there is an expectation that electric vehicles are to take 3.5Twh, 9% of world electricity demand and will be

using recyclable and rechargeable batteries (New Energy Outlook, 2018; World Energy Outlook, 2018). This means that the cost of batteries will reduce as the demand for batteries reduces (Zhang and Yao, 2019). Olabi (2017) concurred that as renewable energy is becoming the global need to create additional power capacity, investment in energy storage facility requires its own infrastructure. There are various energy storage techniques such as magnetic systems, pneumatics and capacitors but the most common are the batteries.

World Energy Outlook (2018) indicated that batteries are part of capital cost requirements for power-infrastructure operation such as when the power has switched off, batteries are used to operate equipment in order to restore power. Zhang, Wei, Cao and Lin (2018) indicated that batteries are optional when power utility is failing to supply the power demand but extremely expensive for power utilities to invest in; however, they are beneficial for the peak load supply to reduce peak demand from power grid.

3.5.3 Increasing imports of electricity from neighbouring countries

In Afghanistan 70% of the population live without electricity and 90% of 70% are in rural areas (Amin and Bernell, 2018). Citing African Development Bank (2015), in their study they found that there are projects initiated and approved since 2002 but there is no construction executed. They continued stating the cost of imported energy has increased from USD $16 million to nearly USD $224 million between 2007 and 2015.

Das, Halder, Mazumder, Saini, Parikh and Parikh (2018) in their Bangladesh study concluded that the reliability of electricity supply means the stability of economic growth. World Energy Outlook (2018) indicated that it is cheaper for most of the developing countries to import electricity services rather than to raise capital for power-infrastructure investment. Globally, power generation has been traditionally coal, hydro and gas World Economic Outlook (2015). In this, the challenge is that there are only 10 countries holding 80% of the world coal reserves and there was no African developing country among countries referred to on Mining-technology.com (2013), as it is still the continuous case.

There are developing countries such as Central African Republic, Seychelles and Djibouti; with very low GDP, very low tax collection (World Bank, 2017), that are incapable of raising capital to develop power-infrastructure. Those developing countries import power from neighboring countries, as coal, wind and gas are considered the cheapest technologies in power generation (International Energy Organizations, 2017). The abundance of gas has been in countries that are mostly in the North Asia (World Nuclear Association, 2017). Capital-investment requirement development of power station vary intensively according to its technology (International Energy Organizations, 2017).

It has been the tradition that these developing countries addresses power shortages through electricity importation rather than to raise capital for power-infrastructure investment (Das et al., 2018; Amin and Bernell, 2018). In some of these African countries such as Central African Republic (CAR), Seychelles, and Djibouti, repayments are impossible to achieve as some have very low income per capita and highly dependent on agriculture for economic growth and sustainability (World Nuclear Association, 2018; Africa Energy, 2018; and International Energy Organizations, 2018).

Sequeira and Santos (2018) stated that the challenge of these developing countries is that they faced high level of political protests against governments, and this affects investments in power-infrastructure. In South Africa, Eskom has surplus of generational capacity but when employees protested in 2018 for salary increases and bonuses, the country started to experience load shedding (Phasiwe, 2018). He continued stating that the country resorted to importing electricity from the neighboring countries.

3.5.4 Variations in domestic versus international market demand

In the study of de Souza and Gómez-Ramírez (2018) in Mexico, regarding exported goods revealed strong economic balances that the exporter has to do to balance between generation and demand, both local and international demand. In the case of the electricity sector, the driver for over electricity generation each day, must be the demand for power for the next day, next week, and next month.

Lopez, Biona and .Chiu (2018) argued that countries with higher income per capita such as Germany, Czech Republic and Netherlands have high carbon emissions and are exporting more electricity compared to those with lower income per capita. Hou and Hou (2018) stated that in order to reduce greenhouse emissions, cross border electricity trading must be true renewable energy. Peleng, Nativ and Richter (2018) argued that is viewed as singularity, highly focused on environmental impact of electricity exportation.

On this, there are two contradicting views that links the direct relationship between electricity exportation and population growth, emanating from CO_2 emissions and magnetic field on high voltage power lines perceived to be causing cancer (Peleg, Nativ and Richter 2018). Firstly, is that Non-Government Organizations (NGO) such as Greenpeace, Green Scorpions have an impact of influencing reduction of foreign fossil fuel imports into their respective countries and promotes renewable energy (Burki, 2013). Thomas (2018) stated that power utilities forecast some of its revenue income on sales export to the neighboring countries, when the demand drops, sales in the exporting power utility also drops meaning revenue-income losses.

The second challenge described by Pfenninger and Keirstead (2015) is that when exports drops the revenue income declines. De Souza and Gómez-Ramírez (2018) supported by Lopez, Biona, and Chiu (2018), stated that electricity generated is for total base load supply which is not instantaneous and

neither is it based on the real-time nor volatility of foreign electricity demand. The third challenge is the priority of meeting the domestic supply versus the international community (De Souza and Gómez-Ramírez, 2018). Reviewing this from the perspective mentioned by Lopez et al. (2018), the decline in the domestic sales and an increase in international sales and revenue income is always the challenge when foreign demand has to be compromised to cater for the sudden increase in domestic demand (Larsen et al, 2018).

The majority of literature is in contradiction with Geginat and Ramalho (2018) in their study of 183 countries where they concluded that the elastic relationship between sales and revenue income, cost of generating electricity and the cost of electricity connections for both residential and industrial growth had low impact on the cost of electricity. In South Africa, Conradie (2019) stated that the expenses related to generating or importing electricity versus the low prices paid by the residential consumers or non-payment practiced by townships including Soweto, argues against the statement raised by Geginat and Ramalho (2018). Thopil and Pouris (2015) summarized it eloquently that when domestic electricity demand increases at lower rates compared to the international rates, the power utility is going to face the revenue income deficit.

3.5.5 The size of the company, if it is too big it is likely to collapse

Larsen at al. (2018) in their study have highlighted that electricity companies in California, Columbia and United Kingdom (UK) collapsed due to financial bankruptcy. Power utilities in South African are facing similar challenges (Green, Sovacool and Hancock, 2015). There are variations in terms of business modelling, but the concept is similar for example (Salling and Leleur, 2015). Larsen et al. (2018) stated that in developed countries, the generation, transmission and distribution are not the monopoly government companies such as Eskom in South Africa.

Investments in power utilities tend to be lower than what is actually required (Worch, Truffer, Kabinga, Eberhard and Markard, 2013). Bridge, Özkaynak and Turhan (2018) stated that in most cases, it is because of lack of knowledge from regulatory authorities regarding the actual cost of service delivery to customers. Yelland (2018) and Blom (2019) stated that South African power utilities are facing declining business confidence level driven by uncertainty of how much the real cost of producing the kilowatt (kW) of electricity is.

3.5.6 The globalization of the company, the power utility

Urpelainen and Yang (2019) after Second World War, governments across the war converged into the creation of monopolies, making assumptions that bulk purchases from each division will be cost effective. The review conducted by Wamukonya (2003) and Besant-Jones (2006) revealed that the

structure of vertically integrated monopolies and technical performance are among reasons some of these power utilities are unable sustain themselves financially.

This is different from what was concluded by Larsen et al. (2018), when conducting the study in Pakistan where he concluded that unbundling generation, transmission and distribution led to unreliability of power supply. Qazi and Jahanzaib (2018) conducted the study related to unbundling of power utilities and concluded that it has a detrimental impact to the security of supply with blackouts which at certain times took up to 8-12 hours.

The globalization has limitations, as state power utilities are resourceful reputable (Frei, Sinsel, Hanafy and Hoppmann, 2018). Some strategies towards globalization aimed at privatization, hoping that it will bring liberalization competitiveness. Urpelainen and Yang (2019) stated that this globalization has made private power utilities to become detrimentally worse than monopolies. Worch et al. (2013) stated that the challenge is that private companies take over power assets with the previous monopolized market but has to raise finance through tariffs and investors, which is a difficult challenge as private companies are failing to keep up with maintenance backlog demand, resources requirements and skills competency.

Bridge, Özkaynak and Turhan, (2018) stated that policies in the power sector are not universally applicable for all monopolies but they vary from country to country. The profitable power utility in another country may not be profitable in another country, due to regulatory laws and policies that are different (Worch et al., 2013).

Wan (2017) emphasized the need for digitization of the company through leveraging on the usage of mobile tools, industrial internet, big data and predictive analysis when transforming power utility towards global standards. Although there are some arguments suggesting that transformation of the power sector towards globalization as a means of creating a future sustainable power sector, but the study conducted in Pakistan presented different results (Larsen at al.,2018).

3.5.7 The ineffective management of technical and non-technical losses

Edison, Neto and Coelho (2013) described technical losses as reduction of power that is happening as the results of resistance or impedance during generation or transmission of power from the source to the consumer. Han and Xiao (2017) described non-technical losses as losses due to illegal connections, meter tempering and non-payment.

Usman, Coppo, Bignucolo and Turri (2018) discussed the increase in technical losses due to introduction of renewable energy technologies distribution network. They believed that the network has intermittent conditions that are not dispatchable as it is the case with renewable energy. Bozorg, Sossan,

Le Boudec and Paolone (2018) stated that with the introduction of stochastic resources such as batteries, losses due to clashing of control and protection technology is mostly likely to increase.

Maravilha, Goulart, Carrano and Campelo (2018) stated that the working integration of the renewable energy resources to the existing power lines may displace the existing technology and that may increase costs to be more than the initial estimation. In that case, Callegari, Szklo and Schaeffer (2018) emphasize that project managers should always review Cost Benefit Analysis (CBA) to ensure that cost overruns do not compromise the initial feasibility study that rendered the investment viable.

The data collected from 401 power plant projects developed between 1936 and 2014 in 57 countries revealed that 90% of mega-infrastructure power generation and power line projects experienced both cost overrun and schedule overrun (Callegari et al. 2018). The mega-infrastructure investments refer to projects with high complexity, high risk, high degree of uncertainty, high intensities of social, environmental and stakeholders' engagement and these projects have capital cost investment in excess of a billion (supported by Awajobi and Jenkins, 2016).

There is very little explanation related to non-technical losses to do, as it refers to the non-payment, illegal connection and meter tempering that affects revenue income. The revenue income will be discussed in the following section.

3.5.8 Ineffective assurance of timeous revenue income payment

McKinsey and Company (2018) conducted the international studies related to timeous payment and concluded that the challenges faced by the power utilities include the inability to have positive balance sheets due to lack of revenue income. Puisa et al. (2018) also conducted the global study investigating liquidities in power utilities. They found that poor balance sheets, poor credit rating, and inability to attract foreign direct investments were amongst causes for power utilities' liquidity.

Beck, Müller-Bloch, and King (2018) conducted a similar study related to the impact of timeous payment of debt for economic development countries such as Kenya. They concluded that debt timeous payment contributes to positive and sustainable economic growth. In the study that was conducted by Kohler (2014), the finding was that failure to pay timely has a revenue income impact to power utilities and to power infrastructural development. Pollet, Staffell and Adamson (2015) and Ruggiero and Luhkonen, (2016) emphasized that in order for power utilities realize positive financially sustainability, restructuring the organization to ensure profitability should be the continuous constant.

Beck et al. (2018) on the same study of power utilities' liquidity concluded that there is interconnection between maladministration and corruption. McKinsey and Company (2018), on the issue of

maladministration, concluded that maladministration has mutually inclusion with corruption. Maladministration and corruption mean there is a lack of stakeholders' involvement (Nevin, 2016).

In the study conducted by Green et al. (2015) related to stakeholders, they stated that the deductions related to stakeholders' complexities made led to challenges related to power utilities' capital power-infrastructure investments (supported by Makovsek, 2014, Nevin, 2016, and Gatzert and Kosub, 2016). Li and Youngho (2015) emphasized that stakeholders have a costly impact in infrastructural development; therefore, their expectations have to be managed without compromise.

Moreover, according to Shin, Kim and Sohn (2017), World Bank conducted studies in 118 countries including in South Africa. Their conclusion was that the involvement of non-state stakeholders in the infrastructure development is one of the Key Success Factor (KSF) compared to the state stakeholders.

In South Africa and many other developing countries, state stakeholders, such as ward councilors, deemed as the requirement for infrastructural development, to be regarded as the protocol (Green et al., 2015). The involvement of politicians as stakeholders complicates what is easy to implement, due to their expectations of which some are personal and driven by greed (Gatzert and Kosub, 2016). Hobson, Lynch, Roberts and Payne (2019) in the study in the United Kingdom have concurred that asset development to the community becomes more successful without the involvement of the state officials such as ward councilors.

In contrary to the above, Meth (2013) opened another debate that the greater the involvement of committees in Cato Crest, Durban, South Africa, led to competition that stagnated housing and water-infrastructure development projects (also supported by Waligo, 2014; Clarke, and Hawkins, 2014).

Waligo et al. (2014) were against Meth (2013), but in support of the findings by Shin et al. (2017) that the involvement of state stakeholders contributes to poor performance in power-infrastructure development. A study conducted in Scotland by Hobson et al. (2018) found that due to stakeholders' complexities, the investors must be fully involved in the infrastructure development project without compromising the involvement of key stakeholders and the community.

Teo and Loosemore (2017) conducted that the study related to the risk in project management and concluded that stakeholders are complex risk, which requires systems thinking approach in order to shift the paradigm in stakeholder analysis for capital power-infrastructure investment.

Summarily, the literature review presented the need for the paradigm shift on extensive reliance from state stakeholders, which are ward councilors to community. It is clear that reliance on these stakeholders for project success is a challenge on its own. Shin et al. (2017) stated that it is an essential

requirement for the involvement of the investor in the infrastructure development. Bekun, Emir and Sarkodie (2019) have indicated that the involvement of World Bank in infrastructural development is starting to gain momentum in South African power utilities including Eskom.

3.6 THE ANALYSIS OF POWER UTILITIES IN AFRICA

World Bank (2017) stated that Middle Income Countries (MIC) and Low-Income Countries (LIC) receives 60% of services by importing services from developed countries. Southern African Power Pool (SAPP, 2019) stated that the challenge in developing countries is the lack of capital, whilst Eskom (2016/17 to 2020/21) corporate plan stated that there is a need to expand services into African countries. Panos, Densing and Volkart (2016) estimated that more than 600 million people are without electricity in Africa with 60% living in Sub-Saharan Africa (SSA).

This was different from what the World Bank Private Participation Infrastructure (PPI) investment reported, as it stated that people living without electricity are mostly in Nigeria, Democratic Republic of Congo, Ethiopia and Ivory Coast. World Bank, African Development Bank and Energy Africa specified that African countries are structured into power pools in order to develop energy infrastructure but acknowledge the challenges common in all African countries. Southern Africa Power Pool (SAPP, 2019) described power-infrastructure challenges in Africa as including the following:

- Insufficient capacity to generate electricity for their domestic demand leading to poor electricity access.
- Insufficient capital investment.
- Poor Information Communication and Technology (ICT) infrastructure development.
- Poor regional electricity integration or interconnectivity (covered under SADC section).
- Backlog for infrastructure maintenance, refurbishment or upgrade.

Kruger (2017) made comparative benefits realization analysis on cost of investments proposed in 2017 for Mexico, Chile and Abu Dhabi for renewable energy investments by Italian and French companies. Blom (2019) stated that such an analysis was based on the cost per kWh for renewable energy in South Africa, during bids for renewable energy by Independent Power Producers (IPPs). Moolman (2017) stated that on average Mexico, Chile and Saudi Arabia (Abu Dhabi) were receiving 25c/kwh compared to South Africa's proposed 80c/kwh. Yelland (2017) stated that South Africa is incurring an expense of 55c/kwh more than what these three countries received for the same period of electricity generation using wind and solar. The costs for IPP in South Africa are therefore expensive (Kåberger, 2018). Justification for continuous investment in IPPs lacks rationale but at present the cost for IPP in South Africa is more expensive compared to the global costing trend (Alfred, 2018).

3.6.1 Insufficient capacity to generate electricity for their domestic demand leading poor electricity access

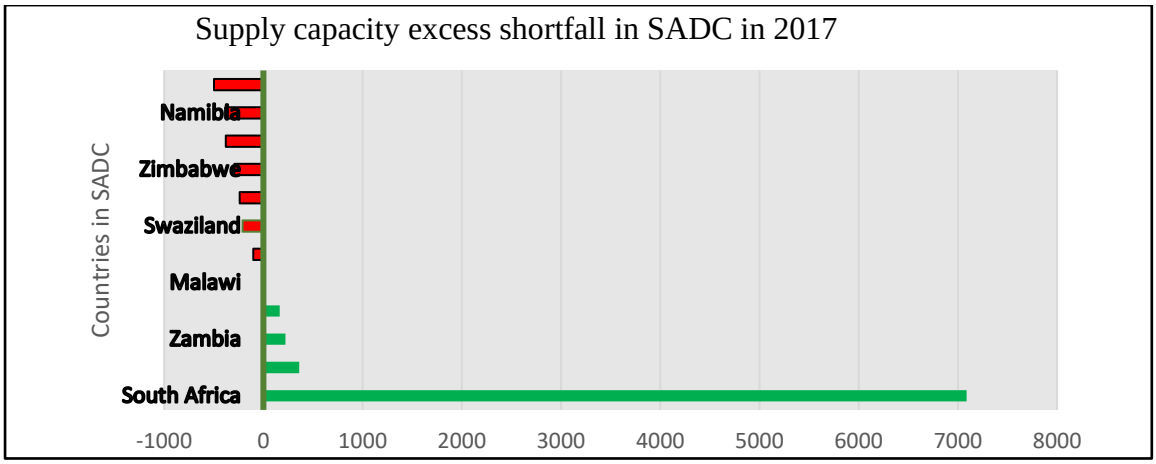
The purpose of this section is to discuss insufficient capacity of power generation more particularly in the SADC region and in the Africa continent as a whole. In this section, the researcher presents the capacity shortfall in African countries and present the installed capacity for South Africa compared to other African SADC countries.

3.6.1.1 Supply power capacity analysis in SADC region compared to South Africa

According to SAPP (2019), when analyzing the installed capacity for countries that are in Southern African Development Countries (SADC), the total installed capacity in 2016 was almost 60GW and reported at 67GW in 2018. South Africa has the supply capacity excess estimated to 71%. In the SADC region, there are countries with electricity supply shortfalls such as Malawi, Swaziland, Botswana, and Namibia. Tanzania, Zambia and Democratic Republic of Congo (DRC). In some of these mentioned countries, the complexity on capital power-infrastructure investment is due to political instability and extended stakeholders' disagreements, which threatens investment security. The typical example for this, is the DRC Grand Inga 3 Project, initially planned for execution in 2014 (Reporter, 2013) but has stalled since then. In 2018, there were no indications that disagreements were being resolved. Almost 90% of the population of DRC have poor access to electricity (World Bank, 2017).

In the following figure 3.6, the study analyzed electricity shortfalls per countries in the SADC region only. The excess capacity that South Africa has, it used to supply neighbouring countries that are unable to raise capital for the construction of power-infrastructure to meet their domestic power demand (this has been discussed in Section 3.5.3).

Figure 3.6: The supply capacity excess in SADC in 2017

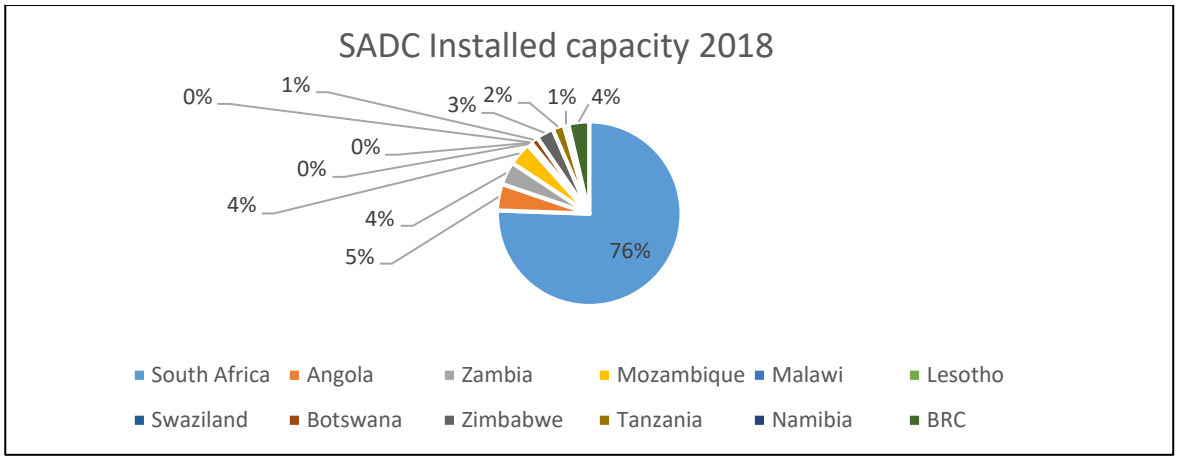


Source: SADC, 2017

Evident from Figure 3.6, it can be seen that there are countries enlisted on the left Y-Axis (vertical scale). There are red and greenish horizontal bars protruding next to each country. The red is protruding towards the left and the greenish line towards the right. The visible country on top is Namibia with red line protruding to the left and at the bottom is South Africa with the greenish line protruding to the right. On the figure 3.6, Y-axis there are countries spaces with bars, without any country name being visible. On top above Namibia, it is Botswana, below Namibia is Democratic Republic of Congo (DRC) and below Swaziland is Lesotho (SAPP, 2017; SADC, 2017). The X-axis (horizontal scale), represents the supply capacity excess in MW (Mega-Watt) of each country in scale numbers starting from zero to 8000 MW. Botswana, Namibia, DRC, Zimbabwe and Malawi are visible having the red line protruding towards less than 0MW indicating the shortfall of electricity. The countries such as Zambia and South Africa

SAPP (2018) stated that the challenge of supply capacity is not only for those countries but hampers the economic growth rate for the region. South Africa, after making international headlines through load shedding, now has excess capacity estimated to 7089MW (Monyei & Adewumi, 2017). Other countries that are having excess capacity include Mozambique, Zambia and Angola (SAPP, 2018). In the following Figure 3.7, are the electricity-installed capacity for individual countries in SADC region. It is visible that other countries in SADC region are still having intensive capital power-infrastructure investment requirements. In 2016, South Africa has surplus capacity of 73%, and in 2018%, 3% increase reported (SAPP, 2018). This has made South Africa to have a surplus capacity of 76% as indicated in Figure 3.7 below.

Figure 3.7: Electricity-installed capacity for SADC region



Source: Southern Africa Power Pool, 2017

The electricity supply-demand as demonstrated in Figure 3.7 for countries in SADC region, translate to stagnation in economic growth (World Economic Outlook, 2018). Africa regardless of slow capital power-infrastructure investment and development remains one of the fastest energy demanding economies (Investopedia, 2019).

3.6.2 Poor information Communication and Technology (ICT) Infrastructure Development

Pradhan, Mallik and Bagchi (2018) stated that ICT is an integral and key requirement for all engineering disciplines. Mgbaka and Agbata (2014) described ICT as the catalyst in the strategic power-infrastructure investments for the assimilation of generation capacity required within the specified timeframe, power-flow, measuring the quality of supply, information or data management, asset life span management and performance.

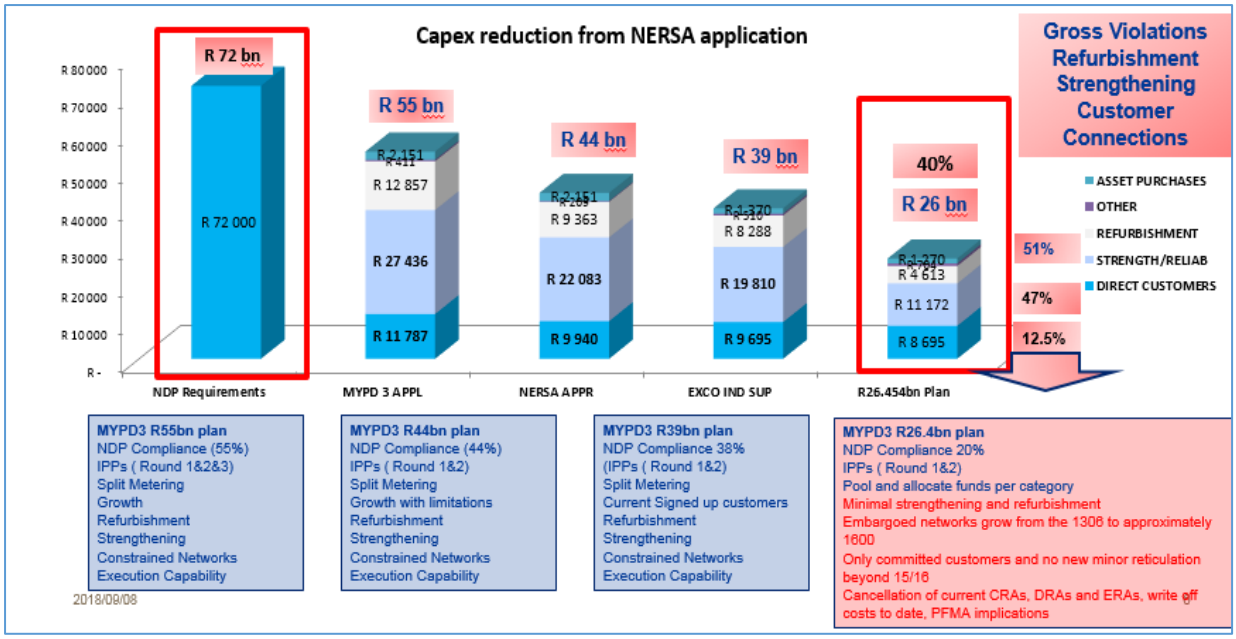
3.6.3 Backlog for infrastructure maintenance, refurbishment or upgrade in Eskom

Statistics South Africa (2016) reported that Eskom spent almost 26% (R73bn) of the total national capital expenditure. Bruno et al (2019) conducted a study on behalf of McKinsey & Co., found that Transmission and Distribution (T&D) have collapsing infrastructure, though in future T&D is most likely to have demanding investments amounting to USD $3 trillion. In the Eskom distribution division alone, there is a continuous decline in capital power-infrastructure investment (Nkosi & Dikgang, 2018). Mayer and Trück (2018) stated that this division is facing what other global power utilities are facing as it is buying power from the generation division, get transmission division to transmit on their

behalf from long distances to distribution infrastructure in power substations and sent for delivery to the user through distribution lines. The demand for upgrading, refurbishment and maintenance of distribution infrastructure has an exponential growing backlog (Ateba & Prinsloo, 2019).

Figure 3.8 shows the 2014 Network Development Plan (NDP), which is the plan compiled from provinces and consolidated to give the national budget requirement.

Figure 3.8: CAPEX reduction from NERSA application



Source: Eskom Executive Committee, 2014

In the above Figure 3.8 it is illustrated that the National Development Plan required R72 billion but on the NERSA submission through the MYPD3 application process, only R55 billion was submitted for grid code compliance, IPP, split metering to recover lost revenue, refurbishment and capacity expansion. Figure 3.8 further illustrates that there was the reduction of grid-code compliance budget approval to the value of R44billion with the strategic plan to do minimal refurbishment and maintenance on the network. The backlog for network upgrade (strengthening had risen), as demonstrated by the number of embargoed networks that had grew from 1306 to 1600. In that era (2013 to 2015), the business took the strategic decision to cancel off CRAs, DRAs and ERAs (Mazibuko, 2013). Pallet (2013) stated that each phase reflected the impact on the strengthening capability and how much impact each submission had on initial Network Development Plan (NDP). Evident from Figure 3.8 is that NDP required R72 billion for however in order to meet the MYPD 3 requirements, a R55 billion was required to achieve 55% network strengthening capability. The lower the network strengthening capabilities submitted such as 44%, 38% and 20%, meant the lower CAPEX budget requirements. As earlier that

power utilities are vertically integrated, this influences tariff increase negotiations and approvals. It also had direct impact on municipal revenue income and economic stability.

Minnaar et al. (2017) stated that among the challenges is that municipalities lack appropriate insulation from political interference of their electricity commercial operation. Mafunisa, Ramabulana, Hlaele, and Nekwakwani (2017) has identified skills shortage as the critical matter in municipalities of South Africa leading to poor infrastructural conditions. Phasiwe (2018) stated that the current power generation status is that there is sufficient surplus of energy reserved for off takers such as mines, commercial or agriculture sector.

Ngidi (2018) and Mkhize (2018) stated that municipalities can be able to be the off takers of Eskom surplus power, grow their distribution capacity but most of municipalities are facing inability to raise capital. Van Deventer (2014) stated that each inadequate power-infrastructure has economic impact and there is a need to balance supply and demand by appropriate priorities when investing.

Eskom corporate plan (2016/17 to 2021) stated that the challenge is that the transmission lines do not have capacity to carry surplus capacity to consumers. IMIESA (2015) concurred with Ngidi (2018) and Mkhize (2018), by stating that the challenge of budget deficit is across all enlisted South African electricity distributors. Salga (2014) supported by export.gov (2017) stated that NERSA has approved Eskom that is currently facing financial challenges with debt exceeding R420 billion, as the licensed Network Service Provider to plan and build the network in accordance with the grid code requirements and with approved methodology to determine Cost of Unserved Energy (COUE).

Minnaar, et al. (2017) stated that COUE is the cost of energy not supplied to the customers due to unplanned short duration of power interruptions, which is less than 3 hours, or planned power interruption lasting more than 3 hours. Conradie (2019) on the public hearing held in Midrand, presented NERSA approval shortage of R450 billion that has led Eskom into a liquidity crisis. He continued stating that possibilities that Eskom will come out of liquidity crisis, through MYPD 4 application for tariff increase approvals.

Nkosi and Dikgang (2018) stated that the challenge for most of these South African electricity distributors are having the weak balance sheets, severely impacted by very low investor confidence and down rating by world financial agencies.
On Eskom corporate plan (2016/17 to 2021), it is clear that the demand for refurbishment and capacity expansion is more than the revenue income. It continued demonstrating that load demand increases and the urgency for plant replacement is getting nearer.

Etxegarai, Eguia, Torres, Buigues and Iturregi (2017) stated that if power utilities are failing to overcome the backlog of power-infrastructure investment, the probability is that they could contravene with regulatory authorities including the grid code compliance or expected national regulatory minimum requirements. This include the following:

- High frequency of power interruptions, which is contravention with the expected quality of supply as legislated National Regulating Standard 047 and 048 (NRS 047 and 048). This standard stipulates that the number of power interruptions per annum and durations per interruption. The electricity act is explicit in terms of its regulation on section 17(1) (d) "The Regulator may revoke a license if the conditions of a license are not met".
- Section 18(4) allows a "penalty of 10% of the annual turnover of the licensee or R2 000 000.00 (whichever is the highest amount) per day" if the licensee is found guilty of contravening its license.
- In terms of section 15 of OH&S act, page 177 of Electrical installation, states that ANY person (including Eskom) who fails to comply with ANY provisions of the regulations shall be guilty of offense and liable upon conviction to a fine or to imprisonment for a maximum period of 12 months.
- It may lead to unsafe distribution of power supply and will compromise grid code compliance in terms of electricity Section 6.1 of distribution license (2006 version) that states that *"If any licensee fails to meet his obligations into this license, the NERSA may serve upon him by post a notice in writing to meet those obligations within 30 days or such longer period as the Regulator may determine, and if the licensee fails to comply with the requirements of the notice-*

  - ✓ *It shall be guilty of an offence and upon conviction be punishable as provided in the Act;*
  - ✓ *The Regulator may recommend to the Minister to authorize an appropriate undertaker to enter upon and take possession of the undertaking of the licensee;*
  - ✓ *The Regulator may withdraw the license at any time"*

3.7 ESKOM, AS THE MAIN POWER SUPPLIER IN SOUTH AFRICA

World Nuclear Association (2018) stated that Eskom supplies 95% in South Africa, and 45% of the African continent with power. However, this power utility is facing exorbitant and ingrained debts owed by the business sector, municipalities and other countries (Rickard, 2015). The indebtedness continues to strive for worse, as the municipalities are unable to recover their revenue from their consumers (Ngidi, 2018). Baleni (2018) stated that South Africa was prominent to the world for selling the cheapest electricity. Inglesi-Lotz (2018) stated that cost of electricity per kWh has always been elastically varying against supply and demand algorithms. Ateba and Prinsloo (2019) stated that it was only after the 2007 load shedding where South African consumers started realizing the exponential electricity tariff increases. It is increasingly becoming more expensive to live in South Africa (Moolman, 2017).

South Africa historically raised their capital borrowing from World Bank or International Monetary Fund (IMF) (Li, 2018). Eskom being the state-owned company raises its capital through the involvement of State as the Guarantor (Khan, Thopil & Lalk, 2016). Kumar, Stauvermann, Loganathan and Kumar (2015) stated that Eskom presents its long terms capital investment requirement to the cabinet for approval before financial borrowing.

Bayer, Schäuble and Ferrari (2018) stated that on their submission for loan approval, the World Bank raised a number of pertinent issues related to South Africa such as:

- an increase in the unemployment level to 50% in youth,
- additional tariff increases and consumer behaviour,
- increased in gender and racial inequality,
- continuous racial and gender exclusion on economics opportunities, and
- Increasing poverty levels.

Converse (2018) further mentioned that South Africa was impacted by economic recession, increased interest rates to the domestic economy (micro-economic scale), and its manifestation to limitation of economic growth and increase in unaffordability leading to non-payment.

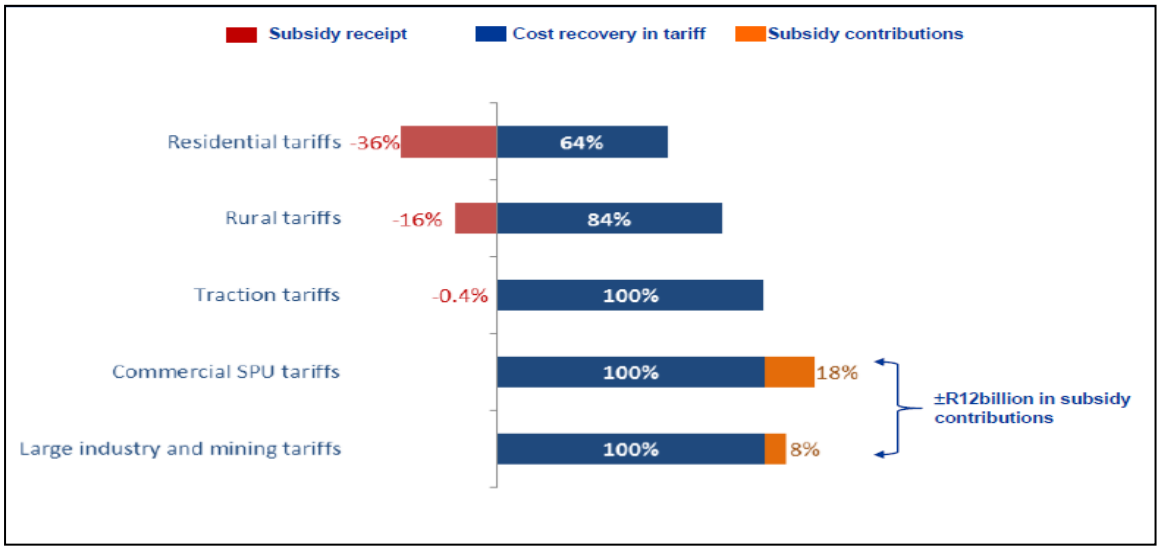
Teimouri and Zietz (2018) conducted the study in 45 high and middle-income countries in Latin American and Asian countries to determine the effect of surgical capital inflow and concluded that the surgical capital inflow does not reduce unemployment. One of the finding on the study conducted by Boero, Mandalinci and Taylor (2019) concurred that, the control of capital-flow in portfolio management for debts and equities in countries, including South Africa, do not have the long-lasting effect.

There are various reasons that could trigger the consumer behaviour or attitude and some of these is the tariff increase adjustment (Paul, 2013). Nicolson, Fell and Huebner (2018), in their study of 27 countries concluded that domestic consumers would prefer the tariffs that are independent to industrial peak demands such as in the morning and also in the afternoon. It is through the systems thinking that the researcher will be able to determine if Nkosi and Dikgang's (2018) views that South African consumers are only willing to pay for reliable electricity supply, are true.

Ye, Koch and Zhang (2018) argued that electricity payment still presents disparities between the property values and amount of electricity each household pays. High frequency of power interruptions due to lack of refurbishment and strengthening projects could lead to unreliable electricity supply (Bos, Chaplin and Mamun, 2018). The revenue income could also lead to inability to invest in capital power-infrastructure (Paul, 2013).

Thopil and Pouris (2015) analyzed countries on Cost of Supply (COS) and Cross-subsidization between domestic and industrial supplies. They initially indicated that 77% of electricity sales is coming from industries that are generating 67% of the revenue income for power utilities. This means that there could be underpricing in industrial sector, with domestic consumers subsidizing the industrial sector (poor subsidizing the rich or employees subsidizing their bosses). Conradie (2018) who is the Eskom Pricing Senior Manager, argued against the views made by Thopil and Pouris (2015). Conradie (2018) explicitly elaborated that the modelling of Eskom tariffs, was such that the business sector subsidizes residential customers as it is presented in Figure 3.9, where customers that are receiving subsidy are evidently depicted.

Figure 3.9: Representing subsidies received per customer area



Source: Conradie, 2018

In the above Figure 3.9, it indicates that the residential customers are receiving 36% subsidization on their tariffs and rural customers with 16% follow them. The rural customers are the majority of customers in Eskom and all other power utilities database (Conradie, 2018). Figure 3.9 illustrates that tractions, which are the railways power supply, are receiving 0.4% subsidy, commercial, large industries and mining are subsiding by 18% and 8% respectively. This would have contributed to the revenue income shortfall totaling to ±R12billion.

Bartnik, Hnydiuk-Stefan and Buryn (2018) stated that there is a difference between the cost of generating electricity and cost of distributing to the consumers. This was in agreement with the argument raised by Conradie (2018) stating that the cost of ensuring that the residential customers receive power is more important than the unit-cost for Kilowatt hour(Kwh) that has to be prized for power utility's revenue income (supported by Baleni, 2018).

Eskom (2019) presented that power utilities submit their capital power-infrastructure investment plans to NERSA. These plans include new capacity creation on the required development based on long-term demand and supply trajectories, maintenance and refurbishment requirement analysis and risks on security of power supply and mitigation strategies, and benefits realization in terms of IRR, ROI, at the end of RCA. Business Unity of South Africa (BUSA), 2018) stated that power utilities review previous submissions as stipulated by NERSA for Prudency Assessment.

In terms of NERSA (2018), it is when the licensee (the one with license to invest, construct, commission, operate and decommission electricity infrastructure) raises tariff to the consumer related services rendered, based on the Allowable Revenue (AR) cost incurred and Required Revenue (RR) costs to determine the future tariff increase (BUSA), 2018).

BUSA (2018) presented that according to NERSA Prudency Assessment of 2018, the justification of long-term capital investment requires licensees, namely Generation, Transmission, Distribution, Exporting/ Importing and Trading to demonstrate the requirement for power-infrastructure capital investment. The necessity of systems thinking is when analyzing the requirements such as answering the causalities to emerging specific questions.

The study that was conducted by Moolman (2017) on electricity payment disparities revealed that the middle income per capita of South Africa in 2017 were paying 44.8% (2017) compared to 15.2% that they were paying in 2007 for 400kwh consumed per month (Further discussion on this is depicted in Figure 3.9). Inglesi-Lotz (2018) stated that the challenge of the South African power-infrastructure investment started in 2007. South Africa was experiencing load shedding due to power generation that was below 8% of the reserve margins (Hallowes, 2011). The load shedding has threatened South African economy (Salling and Leleur (2015).

The impact of load shedding resulted in large power users, in the private and public sectors to having to reduce energy consumption by 10% per day. This load shedding took place on rotational schedule basis (Slabbert, 2015). Nevin (2016) stated that unfortunately the load shedding is among causes that led to the reduction in Gross Domestic Products (GDPs) and the loss of business revenue income. Eskom stated the cause for load shedding was under-investment though the demand growth forecasts are to withstand the growth rate of 6% per annum (Li & Youngho, 2015).

This created the argument raised by Vavi (2008), the Secretary General of Cosatu, as the GDP between 1996 and 2004 has always been growing at an average of 3.1% (Statssa, P0441, GDP, 1993 to 2005). This epitomized that the load growth was more rapid than the economic growth projections (Odhiambo, 2009). Load shedding had a detrimental effect on the local production economy and jobs securities (Nakumuryango & Inglesi-Lots, 2016).

The former President, Thabo Mbeki, who was then President of South Africa from 1999 to 2007 apologized on behalf of the South African government and admitted that capital power-infrastructure investment was supposed to get better priority (SAPA, 2007). On this, the emphasis was that municipalities are critical and key stakeholders for country's power availability and their payments was pivotal displayed. Eskom's revenue owed by municipalities amounted to R4.6 billion in 2015 (Moodley, 2015).

Eskom inadequacy of supplying power demand led to stakeholders' unhappiness (Jina, Zhangb, Shic and Ju, 2014). Makovsek (2014) described stakeholders as persons on which the success and failure of every project or investment is dependent upon. The examples of these persons are residential or business customers, suppliers or contractual workers and the public that are actively involved or affected by that development (Heldeman, 2009).

The Project Management Book of Knowledge (PMBOK, 2013) describes the stakeholders as the people that have interest in the project or affected by the project. It further says that the project is only complete when its objectives have satisfied or exceeded the expectations of the stakeholders, which in this instance the satisfaction of customers or all stakeholders in South Africa will be the sustainable availability of power supply.

In order to achieve sustainable availability of power supply Kazadi et al. (2016) supported the views expressed by Crespin-Mazet, Havenvid and Linne (2015) that the involvement of external stakeholders in the co-creation of any product or project is of paramount importance.

Crespin-Mazet et al. (2015) cited Waligo et al. (2014) stating that stakeholders can also create the divergent views, distrust and conflict due to competing interests and values, between stakeholders although it creates knowledge to the leading firm. The main challenge of projects is that stakeholders

have competing expectation (Makovsek, 2014) supported by (Kazadi, et al., 2016). On these Kazadi et al. (2016), further argued that inadequate cost estimations for implementation, development, overall total cost of asset ownership and value engineering, are still among global challenges facing power-infrastructure capital investments, which according to Salling and Leleur (2015) leads to severe disintegration of socio-economic performance.

The shortage of power-infrastructure triggered government to implement power-infrastructure development plans, which included Mega-Infrastructure projects such as Medupi and Kusile coal, fired power stations (Moloi, 2018). Medupi and Kusile capital power-infrastructure investments were through debt acquisition from the International Bank for Reconstruction and Development, which is the largest international bank with the mission to support the World Bank in providing loans to middle and low-income countries (World Bank, 2018).

Yelland (2015) stated government embarked on a Renewable Energy Independent Power Producer Procurement Program (REIPPPP), through the year 2010 using the Integrated Resource Plan (IRP), (2010). The REIPPP resulted in the strategic sourcing of wind and solar energy technologies (Gatzert & Kosub, 2016). In 2018, the Minister of Energy, Mr Jeff Hadebe, has announced R55.92 billion investment in the energy sector highly focused on Independent Power Producers (IPPs) (South African Wind Energy Association (SAWEA), 2018)

Slabbert (2015) citing Silus Zimu, raised concerns that the capital investment in renewable energy will have exponential revenue income deficiency and it will exert more financial pressure towards Eskom, because Eskom is reliant on some businesses that are their main revenue generators. The change of these companies towards installing PV Solar panels on top of their roofs will result in Eskom revenue income deficit (Li & Youngho, 2015). Google, which is the search engine has invested R103 millions in Upington, Northern Cape, South Africa, for solar PV off grid technology (SAinforeporter, 2013). The aggressive appetite by South African government to invest on renewable energy and pursue DRC for mega capital investment, Grand Inga Project 3 hydropower, has constraints.

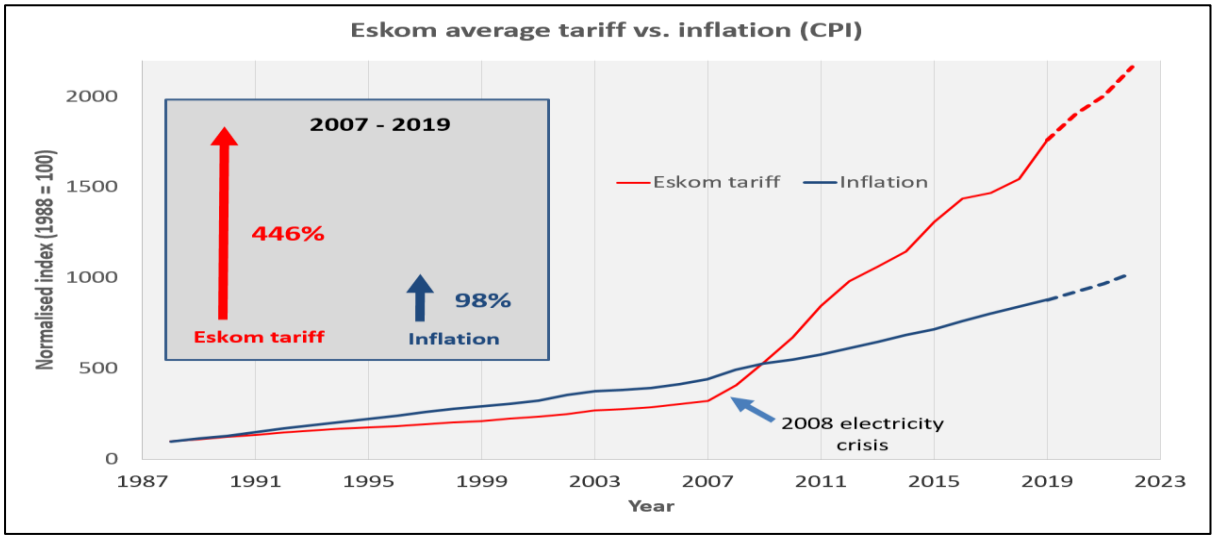
These cross-border transmission lines to South Africa dichotomized investment direction that South Africa is to pursue non-fossil power-infrastructure investment (Gatzert & Kosub, 2016). Kazadi et al. (2016) mentioned that part of these investments includes Grand Inga project 3, which was supposed to start in October 2015 and towards the end of 2018, Grand Inga Project 3 had not started.

The need for South Africa to invest more in renewable energy is an environmental compliance requirement. South Africa, the seventh largest coal exporter, is a negative contributor to CO_2 due to the fact that 90% of power is from abundance of coal (Nakumuryango & Inglesi-Lots, 2016). They further

stated that South Africa has the best performing economic indicators compared to other African countries, but it is among the worst performers in renewable energy.

Yelland (2015) have warned investors of the surgical approach towards renewable energy, without having a proper regulating framework. He stated that South Africa is not different from China, Spain, and Mexico regarding renewable energy. In this, he was referring towards pricing of renewable energy. Moolman (2019) measured the electricity increases since 2007, he stated that the financing power-infrastructure in South Africa has resulted in an electricity rate increase of 356% in 2017 and by 446% in 2019 since 2007, which is more than the inflation increase of 74% and is presented in the following Figure 3.10.

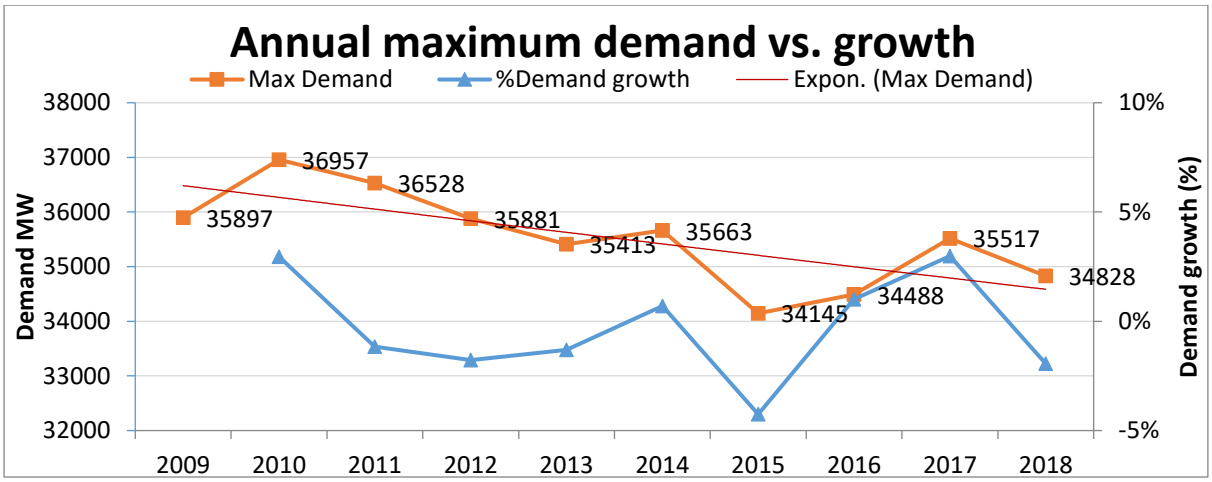
Figure 3.10: Electricity increase between 2007 and 2019



Source: Moolman, 2019

Evident from Figure 3.10, is that the red line indicates Eskom tariff increase and the blue line indicates the inflation rate since year 2007. This increase in the tariff has been through proper regulation by NERSA. Moolman (2019) further analyzed the tariffs' impact on the residential middle-income per capita for affordability in 2020/21. The analysis revealed that electricity will continue being more expensive and unaffordable. This expensive electricity has results into consumers seeking alternative energy sources. Ntusi (2018) presented the uncapped declining graph in electricity demand since 2009, as presented in the following Figure 3.11

Figure 3.11: The decline in electricity demand since 2009



Source: Ntusi 2018

Figure 3.11 is presenting the decline in sales and the relative analysis in comparison with the studies conducted by Moolman (2017). In Figure 3.11 there are two lines, there is a red line that depicts the maximum demand and a blue line that depicts the percentage of the demand growth. The maximum demand means the demand that Eskom power has to supply. The percentage of maximum demand growth measures the percentage the demand grows or decline by on annual basis.

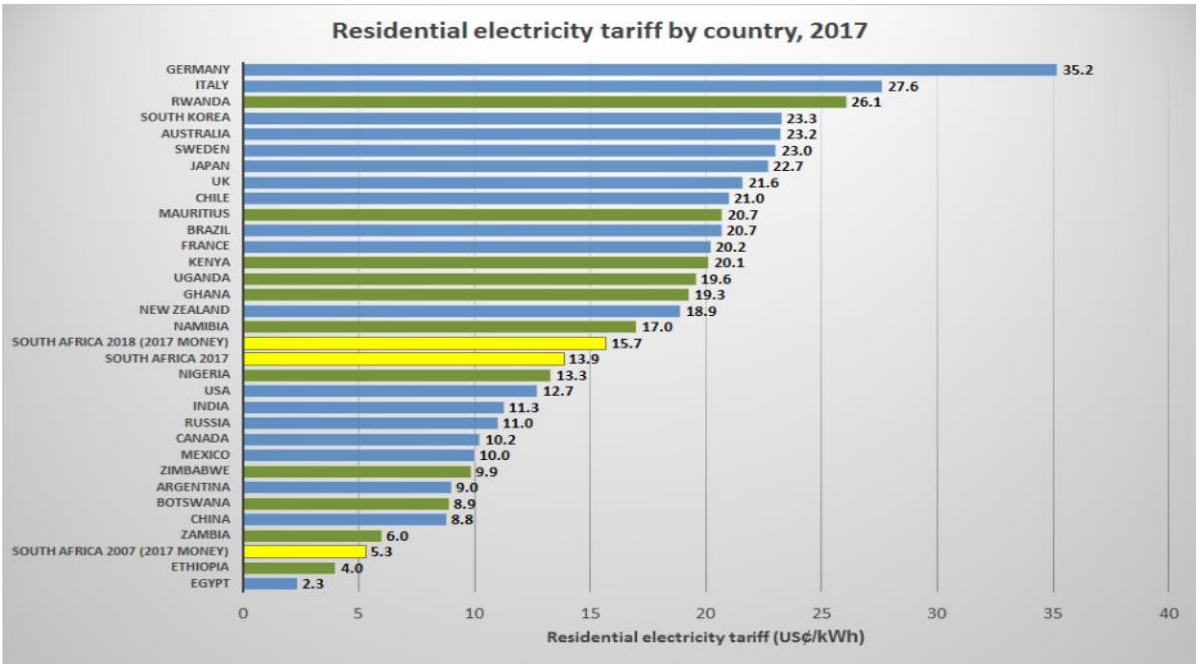
In 2008, there were three consecutive tariffs increase applications for approval to NERSA after Eskom experienced repetitive load shedding (Conradie, 2018). These tariffs increase applications were to recover incurred revenues lost through the RCA process and secondly to expand capacity in order to be able to supply the 2010 Soccer World Cup forecasted capacity demand (Conradie, 2018).

This seriously affected the Intensive Energy User Groups (IEUGs) (Lin and Wesseh, 2014). In 2010, the increase in electricity demand was as the result oversupply of hotels and sport stadiums with electricity due to 2010 soccer world cup (Bond & Cottle, 2011). Figure 3.11 indicates that after the 2010 Soccer World Cup, there has been the continuous reduction in power demand due to consumers looking for alternative energy supply (Bayer et al., 2018).

Cordeur (2015) interviewed then acting Chief Executive Officer, Mr Brian Molefe, who assured investors that Eskom was not a sinking ship, the demand grew again, until Molefe was inaugurated to be the member of parliament, it then started falling again. The continuous electricity price increase as demonstrated Figure 3.12 starting from 2007 to 2017 indicates the impact of tariff increase to the world electricity pricing. The reaction of residential customers towards price increases manifest itself through seeking alternative energy supply (Yan, Ozturk, Hu, and Song, 2018). Figure 3.12 depicts the ranking

of residential electricity tariffs in South Africa as compared to some of the developed economies such as USA, India, Russia, and China.

Figure 3.12: Residential electricity tariffs by country, 2017



Source: Moolman, 2018

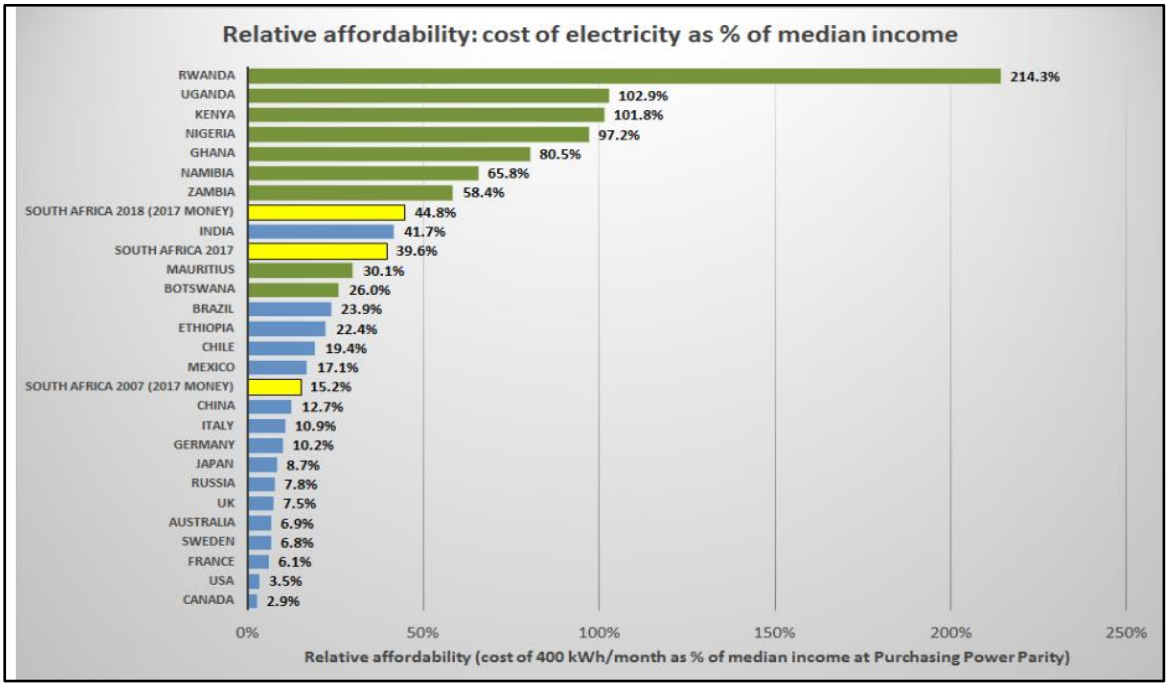
Evident from Figure 3.12, is that there is distinction of countries using three colours such as blue, green and yellow. South Africa is appearing with the distinction of yellow colour, all other African countries (with the exception of Egypt) are in green and all other developed countries are in blue (including Egypt mistakenly labelled blue). The economic indicators (countryeconomy.com, 2019) argues against Moolman (2017) to label Egypt as the developed country. The example for this, is that in 2019, the annual GDP for Egypt was $302M compared to South Africa ($351M), Stock exchange for Egypt was 0.23% and for South Africa it was 9.91%.

Further to that, according to Human Development Index (HDI) (2021), Seychelles with 0.801 and Mauritius with 0.796 are leading Egypt with 0.7. Therefore, Egypt is among all other African developing economies, it is not the developed country (African Union, 2020). Egypt at the bottom, in blue, is misrepresented as a non-African country, as all other African countries are developing, this is the case with Moolman (2017).

In Figure 3.12 that between 2007 and 2017, found that, the situation of Italy is such that people living with children, tenants, and people living in poorly maintained homes are struggling to pay for electricity (Miniaci, Scarpa and Valbonesi, 2014). In South African middle-income urban households have

experienced an increase from USD $5.3 to USD $15.7 (see yellow on Figure 3.13 below) for every 400kwh of electricity consumed per month. The USA, which is ranked as number one country in terms of development and GDP growth rate, has electricity that is costing less than that of South African residents, but they have complained of the electricity affordability (Jeon, Lee & Wang, 2019).

Figure 3.13: The relative affordability: Cost of electricity as % of median income



Source: Moolman, 2018

In Figure 3.13, South Africa is presented in yellow; developing countries are in green and developed countries in blue. Moolman (2017) categorized Ethiopia as a developed country between Brazil and Chile. Ethiopia is an African developing country with low GDP compared to South Africa. The Worldometer (2017), which ranks in comparison all countries in the world, presented GDP per capita comparison.

In that ranking, USA is ranked as number one with the nominal GDP of $19.485 trillion (24.08% of the world share), South Africa as number 32 with the nominal GDP of $349 billion (0.43% of the world share) and Ethiopia as number 66 with the nominal GDP of $80.56 billion (0.10% of the world share).

In addition, the World Bank (2018), World Energy Outlook (2018), and World Nuclear Association (2019) categorized Ethiopia as a developing country, not the developed. The World Bank (2019) pronouncement that Ethiopia had strong, broad-based growth economy that averaged at 10.3% a year

from 2005/06 to 2015/16 might have mislead Moolman (2017). Further to that, it might have created the misconception that Ethiopia is a developed country in the region of Africa.

In Figure 3.13, the study presents that the cost of electricity in South Africa (44.8%) is higher compared to developed countries such as USA (3.5%), UK (7.5%), Russia (7.8%), France (6.1%), Canada (2.9%), Germany (10.2%) and Brazil (23.9%). The Worldometer (2017) described all above-mentioned countries as having higher GDPs per capita with the world ranking of USA (1), UK (6), Russia (11), France (7), Canada (10), Germany (4) and Brazil (8).

The increases of electricity prices in South Africa, maximum demand leading to load shedding, tariff increases, and affordability are historical demonstrations of how Eskom financial challenges have evolved (Baleni, 2018; Conradie, 2018). The deductions, based on the figures, on the comparison of electricity affordability between the developed and developing countries is that some of the developed countries have cheaper electricity prices than South Africa as a developing country (Moolman, 2019).

The review on the World debt clock (2019) regarding the national debts in the world indicated that electricity cost in South Africa is higher than for countries with national debts and with higher GDPs. There is no justified correlation between the countries that are having the biggest national debts and high tax (further review of this topic in section 3.9).

The causes for non-linear electricity cost between the developed and developing countries have many variations such as generating technology used (Koko, 2016), country's credit rating (Ballester and González-Urteaga, 2017). South Africa has nuclear power plant as earlier explained. The development of nuclear power plant is capital intensive (Lurshina, Karpov, Kirkegaand and Semenov, 2019).

In Figure 3.14, this study investigates costs per technology. This is because there are countries with the large national debts that are paying lower electricity prices than what South Africans are paying (Moolman, 2017). Ansa et al. (2016) stated that China, for example, has the largest world debt estimated at R28 trillion more than the total debt of US, Japan and Germany combined as listed. Kruger (2017), Moolman (2017) and Alfred (2018) have all concurred that developed countries are receiving lower rates compared to developing countries.

Earlier in this chapter, there was deliberation that the electricity cost increase in South Africa is through the approval process of the regulating body (NERSA, 2018). Further to that, it was stated that MYPD process include CAPEX, OPEX and reconciliation of the cost incurred from previous approvals, through the RCA process when applying for tariff increase (Joubert, 2018).

Writer (2018) reported that Eskom looting could be in the region of R500 billion starting from 2005 from the construction of Medupi, Kusile and Ingula mega-infrastructure investments. The recovery of this looted money is unfair and unjustifiable to taxpayers (Gaffney, 2016).

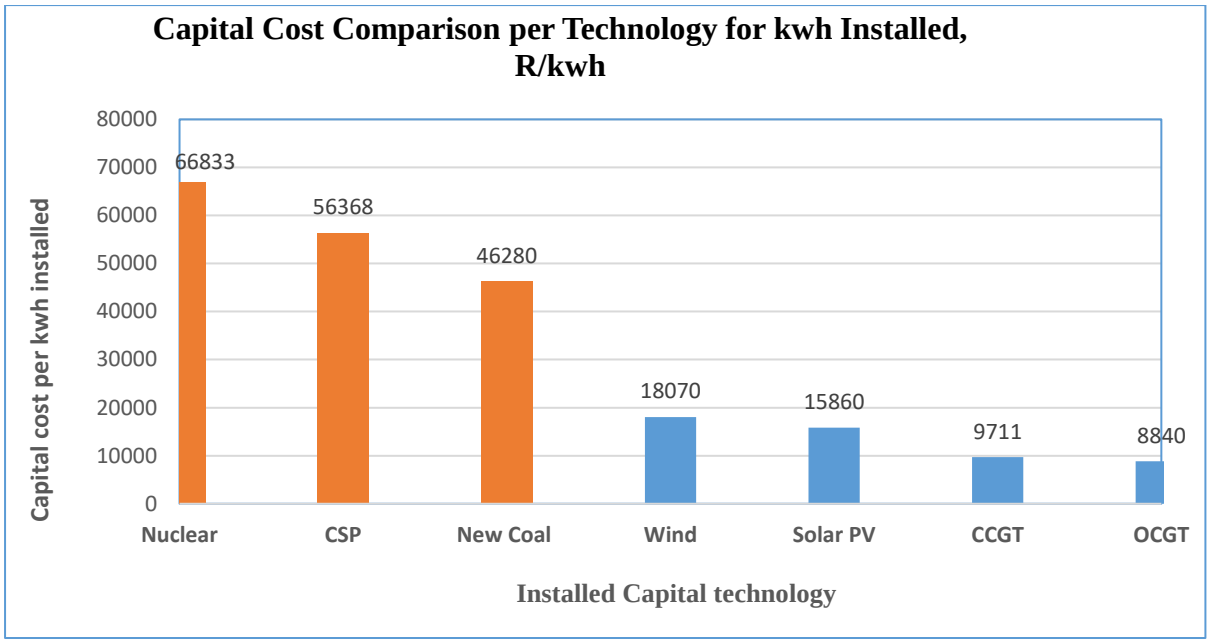
This drives EIUGs to investigate alternative sources of energy supply in order to pay for tax that is fair and justifiable (Bayer et al. 2018). The emergency of renewable energy and decline in grid infrastructure is as the results of business confidence decline in the power utility's grid (Eskom, 2015; Mabuza, 2018).

Yelland (2015) cautioned to the surgical approach towards investment in renewable energy, as it could lead to insolvencies as experienced by Abengoa, a solar power in Northern Cape Province, South Africa, which led the company to have consolidated debts of R137bn in November 2015. He continued stating that their potential investor, Gonvarri Corporacio, never approved a capital injection of R5.3bn and further stated that it resulted in Abengoa share price to tumble by 54% that day.

The procurement of this fleet of renewable energy power plants is inclusive of Power Purchasing Agreement (PPA) with the state-owned company, Eskom as the main power off-taker (World Bank, 2018). This PPA was reached when Eskom had frequent power failures and capital deployment for Medupi and Kusile coal fired power stations was not finalized (Davies et al., 2019) and Bruck et al. (2018), described that every Cost of Energy (COE) as part of PPA. Bruck et al., (2018) continued stating that regardless of the technology installed in any country, the negotiation and assessments must be through Levelized Cost of Energy (LCOE).

Nissen and Harfst (2019) have argued that the traditional application of LCOE which include operation and maintenance, political factors, environmental, capital investment, insurance, are not appropriate for long term investments, as it lack price fluctuations. If that is the case, it will answer why power utilities are unable to services their debts. In the following Figure 3.14, the costs related to generating power in Kwh as part of assessing what could be cheapest investments technologies to consider, is presented.

Figure 3.14: Capital costs comparison per technology for power installed



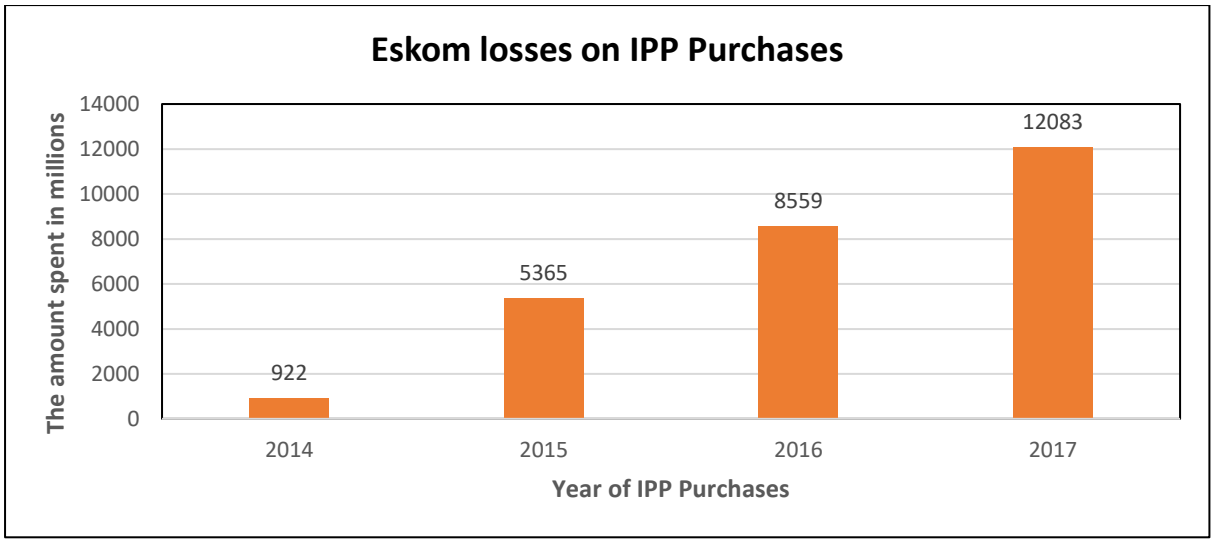
Source: Eberhard and Lovins (2018)

Figure 3.14 above indicates the LCOE for various technologies based on the analysis done in 2017. The LCOE for Open Gas Circle Turbines (OGCT) has the lowest capital cost for kwh installed, 8840Mhw and it is followed by Combined Circle Gas Turbine (CCGT), 9711Mwh. In the Figure 3.14 above the top three, most expensive technologies are nuclear, solar CSP and new coal power plants (Eberhard and Lovins, 2018).

Nuclear is unnecessary and costly (Gigaba, 2017). Nuclear is the followed by Solar CSP, such investment projects are already in construction progress status in South Africa, awarded in order to meet electrification of 179 000 households (Solarpaces, 2018) and ensure energy mix (Akgün, Keskin and Byrne, 2014 and further supported by Radebe, 2018). Wind is appearing expensive compared to solar PV (Eberhard and Lovins, 2018). Eskom has reported continuous loss of money from these IPPs.

Koko (2016) when he was acting as Group Chief Executive continued to emphasize that IPPs are continuing to loot Eskom from unrecoverable and exponentially growing billions of rand. Eskom financial statement 2018 revealed the drastic increase in IPP energy purchases starting from R922 million in 2014 to just above R12 billion in 2017. Renewable Energy, except for nuclear, is unreliable for baseload supply (Cilliers, 2018). In the following Figure 3.15, is the data presenting purchases done on the IPPs.

Figure 3.15: Eskom losses on IPP Purchases



Source: Eskom financial results (2018)

In the above Figure 3.15, it is evident that the amount spent on IPPs continues to increase since 2014. There has been up to round three of Renewable Energy Independent Power Producer Procurement Programmes (REIPPPP). The increase amount from 2014 to 2015 is 481%, 2015 to 2016 is 59.5% and 2016 to 2017 is 41%. Koko (2016) revealed that the amount spent on IPP purchases does not justify return on investments such that then it was costing Eskom 188.40c/kwh to purchase power from IPP and Eskom can only be able to sell at the market price of 83.60c/kwh with the loss per kwh of R104.80 c/kwh sold. In four years starting from 2014 to 2017 the unit purchase price has led to the gross loss of 1211%, R12 billion. This Power Purchasing Agreement (PPA) included the interest rate of 12% per annum for 20 years, which is more than what European countries were receiving (Ateba & Prinsloo, 2019).

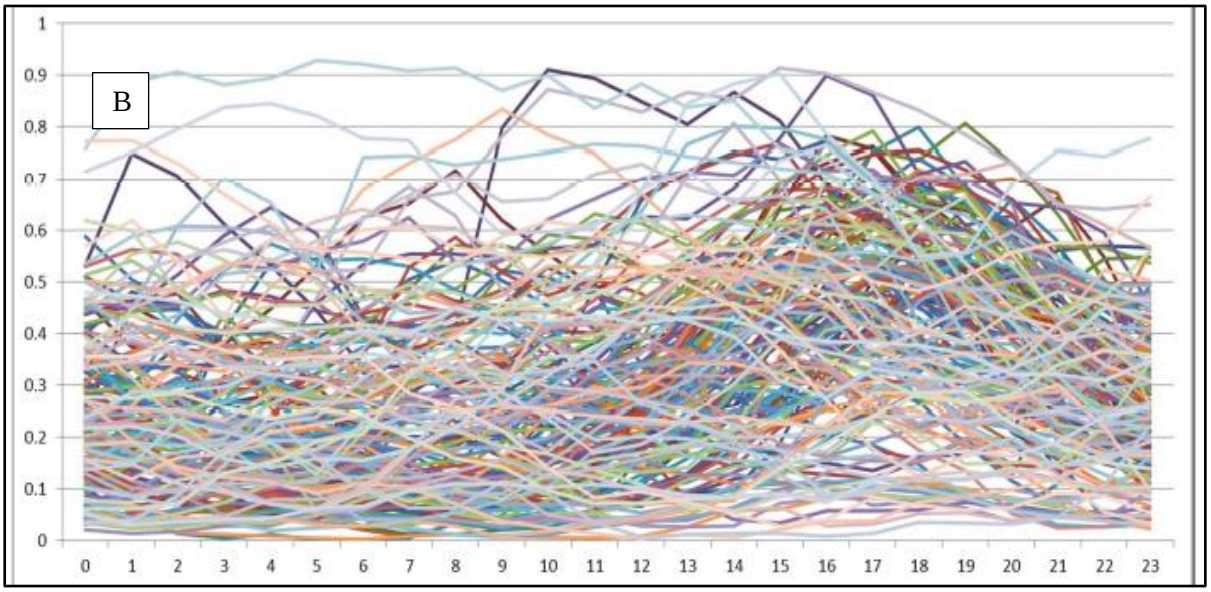
When the President of South Africa, Mr Cyril Ramaphosa, reshuffled the cabinet and Minister Jeff Hadebe became the Minister of Energy who promised to sign additional IPPs, there were protests. The trade unions were protesting insinuating that IPPs were going to lead Eskom into financial liquidity and retrenchments (Koko, 2018). The protests related to possible job losses is an inevitable global trend when there is a change (Eskom media, 2017). The IPPs have ability of job creation, but there is no evidence that these IPPs will be able to absorb people that currently employed by coal-fired power stations and at the risk of retrenchment.

Ntusi (2017) presented daily wind power flow, based on 15 wind power plants in South Africa. He further presented how the unpredictability of wind relates to power generation complications. It was evident that unlike predictable solar, which is normally stronger during midday, wind can even be

stronger by 6am to 8am. This is the peak-energy demand time and a lot of power generated to withstand the demand due to cold load peak-up. Wind can further be stronger in hours between 6-9pm.

The data from Eskom National Power Control Centre (ENCC) as evident from Figure 3.16 demonstrated the wind load flow and demand analysis. This data analysis included the energy flow including for the renewable energy stations. The analysis revealed that the unpredictability of wind strength whilst there is baseload supply might lead to excessive availability of power supply in the grid. Ntusi (2017) continued presenting, as presented in the following Figure 3.16 below.

Figure 3.16: The daily records for wind power-flow recorded in Eskom National Control Centre from 15 wind power plants



Source: Ntusi (2017; 2018)

Figure 3.16 above has Y axis starting from 0 to 1 in increments of 0.1. These Y-axis numbers represent the base-load supply power factor. There are fifteen wind power stations existing and they may not all have the same output; some will be 5MW, 10MW, 30MW and some 50MW. Ntusi (2018) stated that *"If you take the wind power station with biggest power output, such as 50MW above. Divide all wind power stations capacities individually such as the following 5MW divide by 50MW, you will get 0.1 and again take 10MW divide by 50MW you will get 0.2 until you get to the same wind power station with the biggest rating such as 50MW divide by 50MW, the answer is 1"*. This is how the Y-axis numbers are constructed. The X-axis numbers are the hours per day starting from midnight 00.00 until midnight 23h59.

In Figure 3.16, each line represents the total power flow that was conducted for all 15 wind power plants in South Africa. All 15-wind power plants normalized to get the combined generational capacity per day. In a simple language, the figure presents the total generational capacity for the day over the period of 24 hours. Each line on the graph represents the aggregate wind power output per each day. Refer to Figure 3.16 and consider the light-blue line at the top labelled as A. In the early hours of a certain morning, all power plants were having total output power of 75% between 00h00 and 01h00 in the morning (see between 0.7 and 0.8 on the Y-axis on the left). The wind strength fluctuated until it exceeded 90%. It is also visible that at 09h00 the wind strength was below 90% hence the recorded generating power output was below 90% (refer to Figure 3.16 above). At approximately 19h00, the generating power output was as low as 50%. Summarily it started as 75%, went to above 90% from 03h30 to 08h30, 50% around 19h00 and 75% again at midnight.

Each day produced varying capacity of energy generation with different amplitude. It is visible that the wind power plants in most days they have generated very unreliable power output and very low estimated at 30% (which is 0.3 of the Y –axis) of the total generation capacity (refer to the figure 3.16, you will see where the group of lines are concentrated together). It is visible from Figure 3.16 above that the generation capacity became stronger for most of the wind power plants in most of the days starting from 13h00 to 20h00. This means that during the early hours of the day the possible power generation is most likely to lead to load shedding, if wind power can be an investment for base load supply.

In Figure 3.16, there is a randomly selected navy-line labelled B. The wind generating capacity starts at 55%. At 01h30 in the early hours of the morning, it increases to 75% at about 08h00, it drops to 35% and increases to more than 90% around 10h30 but end just below 50% after 23h00. This wind power-generation fluctuation determines the unreliability of wind power on the base load supply.

3.7.1 Review of Generating Power Technologies

The following section presents the literature review on seven power technologies, together with their advantages and disadvantages. The foundational understanding of most of these technologies have been discussed in this chapter, in Section 3.2 supported by grid map in Figure 3.1. It was elaborated that most coal-fired power stations are in Mpumalanga and Limpopo province, the nuclear power plant in Western Cape, the hydropower plants such as Drakensberg power stations in KwaZulu Natal and there are landfill sites in different provinces.

The first technology to be discussed is wind technology in section 3.7.1. The investment in wind power stations is the offshore investment of building protruding aerodynamics and noisy rotating blades, called wind turbines, to generate electricity (Onakpoya, O'Sullivan, Thompson, and Heneghan, 2015).

3.7.1.1 Advantages of wind technology

- Wind power is cheaper than coal fired power, as the fossil fuel is costing between two to six cents per kilowatt-hour (Partridge, 2018).
- Wind is a natural resource; it then becomes the natural commodity to fuel power plant (World Economic Outlook, 2018).
- It can create long binding Power Purchasing Agreement (PPA) of up to 20 years and reduces the legal liabilities between the supplier and off-taker (World Bank, 2018).
- It creates employment opportunities for manufacturing, implementation, monitoring and maintenance of the power plant (Lane, 2018).
- Wind is the clean natural source of energy and it does not have a pollution impact such as coal or fossil fuel (Burki, 2013).
- Wind has the relationship with sun, as the heating of wind particles produces movement through kinetic energy (Wiser & Bolinger, 2016).
- Schmidt, Born, Schneider (2012) stated that wind power plant can be built either in town or in rural areas if there is wind.

3.7.1.2 Disadvantages of wind technology

- The availability of strong wind current is only for 1/3 of time per 24 hours/per day circle. Strong wind currents are mostly during the night when power demand is low (Department of Environmental Affairs, 2014).
- In most cases, wind is freely flowing away from the cities and demands building transmission lines from rural areas to the city (US DOE, 2015).
- The spinning turbines have killed many wildlife species such as birds (Li et al., 2015).
- The protrusion of wind turbines distorts the environmental view (Chen et al. 2018).
- The rotation of wind turbines is noisy that could affect the surrounding (Li, 2018).
- Wind is not environmental friendly to all kinds of birds, more in particular those flying at night as they get killed by the rotating blades (Bakker, Pedersen, Vvan den Berg, Stewart, Lok & Bouma, 2012).

3.7.2 Investment in Solar Power Stations Technology

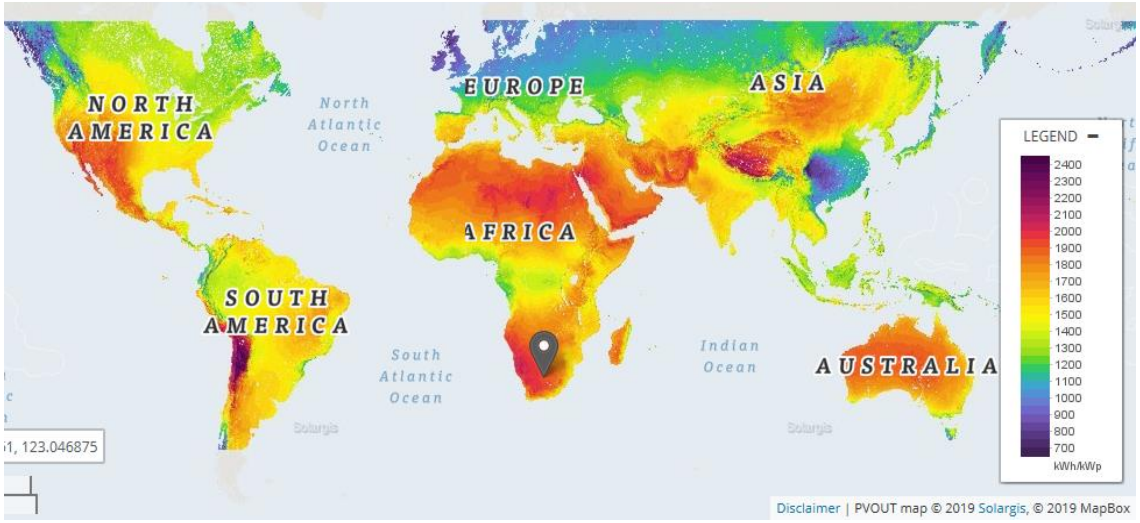
Africa is the continent with very good sunrays (World heat map, 2018). South Africa have invested in solar power plants mostly situated in Northern Cape (Yelland, 2015). According to Department of Environmental Affairs (DEA), (2019), solar energy is the sunlight energy converted into electricity mostly by using photovoltaic material or Concentrated Solar Plants (CSP). The strength of the solar power is dependent on the strength of the sun arrays in that region (Phillips, 2019).

Phillips (2019) described solar energy as the fastest growing technology, most profitable and cost-effective investment for power utilities. He continued stating that the only obstacle to solar energy growth is the competition raised by fossil fuel companies that are politicizing solar energy consumption.

Davis and Lowell (2018) described that among many political reasons, solar energy is leading to high mortality rate and shortage of lifespan of community where it is installed. They continued stating that there is a correlation between areas where there is solar and the lifespan due to exposure to solar energy. African continent has the best sunrays (Shortall, Davidsdottir & Axelsson, 2015).

In the following Figure 3.17, the global regional view of areas with the best sunrays that could produce better solar energy is illustrated. South Africa is the third best solar location in the world and ranking the seventh in terms of investment attractiveness (Africa Check, 2015 citing Greenpeace, 2015).

Figure 3.17: The map of sunrays in the world, it demonstrating, the effectiveness of South Africa



Source: World Bank Group, 2019.

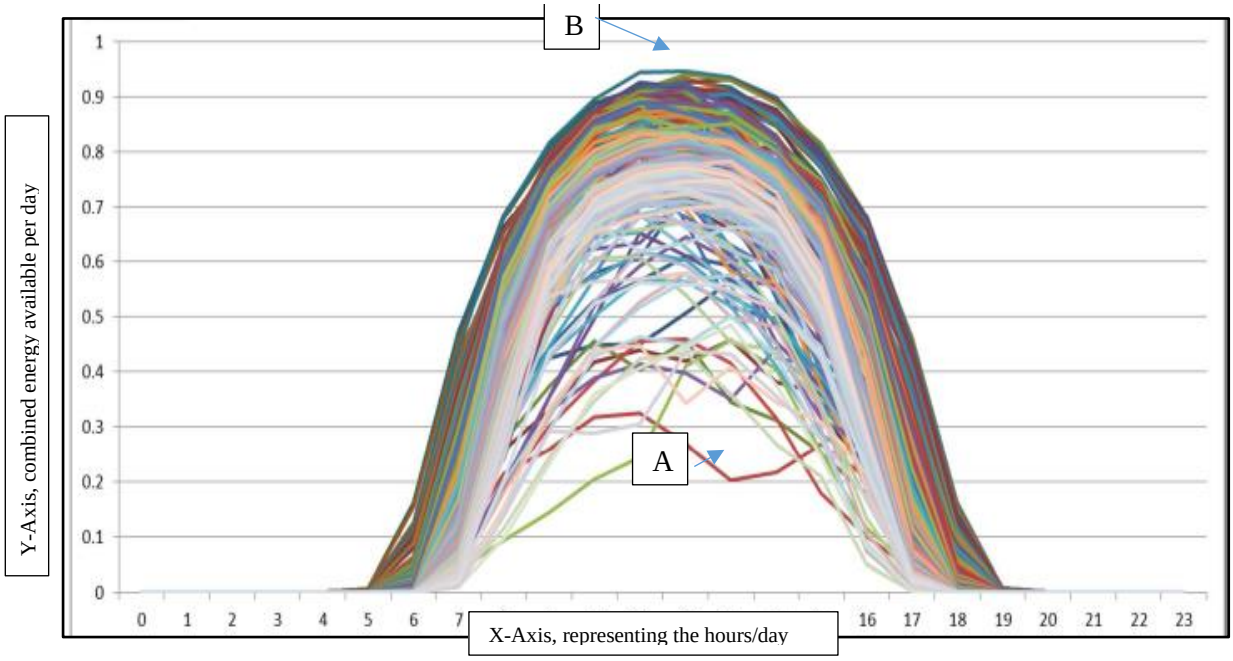
On the Figure 3.17 above, there are different colors described on the legend, bottom right corner as starting from low too high in terms of energy intensity. The reddish section indicates the section where

the pyrometer, which is the measurement for wavelength radiation, a type of actinometer, measured solar irradiance on a planar surface and designed to measure the solar radiation flux density (W/m2).

On the Figure 3.17 above, it is visible that South America and the entire Africa continent are the major beneficial continents for high sunrays. Areas such as Ireland and UK do not have good sunrays. South Africa has areas with good sunrays such as Northern Cape Province. According to World Bank (2015) and World Bank Group, (2019), Southern Africa has high solar radiations compared to Central African countries. This makes Southern Africa considered among other best regions appropriate for solar energy investments (World Bank Group, 2019).

ENCC reveals the power generation strength is as presented in the following Figure 3.18 below, the power generation of solar power plants in various days (Ntusi, 2018). The generating output in all days have been proven predicable peaking midday in all the days of measurement. Solar is predictable better than wind, however it is Self-Dispatching source of energy (Ntusi, 2018).

Figure 3.18: Presents solar power plants generating electricity through sunrays



Source: Ntusi, (2017 and 2018)

Figure 3.18 above indicates power generated from various solar power stations and monitored in Eskom National Control Centre (ENCC). The figure that represents the total power generated per day from all wind power stations connected to the grid in South Africa. Different lines of different colors illustrate different days of solar power measurement. The horizontal X- axis represents number of hours per day. On the vertical axis, numbers from zero to one represents solar power generation from 0% to 100%.

For instance, 0.2 means 20% total wind generation to the grid, 0.6 means 60% and so on. Let us look at line labelled A, at 13h00, during the afternoon, all wind power stations were generating 20% of the installed wind power capacity into the grid on that measured day. The letter B on Figure 3.18; shows solar strength or radiation at around 12h00 midday, evident that the solar power stations were generating approximately 95% of their total installed capacity.

The measurement of the total wind generated is instrumentally measured but the first principle exists calculated by understanding that solar power stations differ in terms of installed capacity. Some will be 5MW, 10MW, 15MW and so on. "If you take the solar power station with biggest power output, such as 15MW above. Divide individual solar power plant capacities such as the following 5MW divide by 15MW, you will get 0.3 recorded on the Y axis and again take 10MW divide by 15MW you will get 0.7 until you get to the same solar power plant with the biggest rating such as 15MW divide by 15MW, the answer is 1" (Ntusi, 2018). This is how the Y-axis numbers are constructed. The X-axis numbers are the hours per day starting from midnight 00.00 until midnight 23h59.

On the Figure 3.18 above, each line represents daily recording of total installed capacity solar power plants in South Africa. There are however lines that peak lower than others (refer to Figure 3.18 again). The lower peaking lines were results of low strength of sunrays, such as when there is an inclement weather for various consecutive days (Ntusi, 2018).

3.7.2.1 Advantages of solar technology

- Solar is sun dependent, so as long as there is sun, solar energy will be naturally available (Eikeland, 2015).
- Solar energy can be used for trading purpose; such as selling excess generated solar energy to the grid during the day at higher rate and buy it back in the afternoon at the low rate (Carlisle, Kane, Solan, Bowman & Joe 2015).
- It is very cheap to maintain, and they have long reliability warranty of 20-25 years (World Bank Group, 2019).
- Solar runs are also using cables, which are very low cost to maintain (World Bank Group, 2019).
- The technology of using solar is constantly developing (Phillips, 2019).

3.7.2.2 Disadvantages of solar technology

- The initial cost of installing solar is high (Yelland, 2015).
- Solar is sunlight dependent, if there are clouds the effectiveness of solar drops (Department of Environmental Affairs, 2019).
- It has to be used immediately or can be stored in large batteries, it then forces the consumer to use the grid during the day and use stored solar energy during the night (World Bank Group, 2019).
- The amount of energy needed is dependent on the number of solar panels installed (Shortall et al, 2015).
- It has some toxic material used during manufacturing (Davis & Lowell, 2018).

3.7.3 Investment on Coal-fired Power Stations

In Chapter 1 and 2, the abundance of coal in South Africa has been emphasized but it has its own environmental complexities.

3.7.3.1 Advantages of this coal-fired power stations investment

- South Africa has abundance of coal reserves mostly in Mpumalanga Province (Monyei & Adewumi, 2017).
- There is reliability on coal as South Africa is still having reserves with possible depletion date of 2126 (Ateba & Prinsloo, 2019).
- South Africa's power stations are mostly coal (Eskom corporate plan, 2016/17 to 2021).
- It is cost effective to burn coal to generate electricity because it is abundant (Monyei & Adewumi, 2017).

3.7.3.2 Disadvantages of coal-fired power stations

- Coal has the waste problems of all energy sources such as Sulphur and nitrogen oxides, organic compounds, heavy metals, radioactive elements, greenhouse gases and a lot of ash (Thengane, Gupta & Mahajani, 2019).
- Coal uses more water up to 3 326 litres/mwh from pre-generating to generating than all other power-generating technologies (Zhang and Yao, 2019).

- The waste from coal-fired power stations requires capital investment on its own to dispose it (Lemly, 2014).
- Building a coal-fired power station is a long and expensive process (Koko, 2016).
- South Africa's coal-fired power stations are concentrated in Mpumalanga, which limits the location options for power stations (Monyei & Adewumi, 2017).

3.7.4 Investment in hydropower stations

Msimanga and Sebitosi (2014) stated that hydropower stations contribute 2% total generation capacity, 3573MW including those owned by municipalities, in South Africa due to seasonal water availability.

3.7.4.1 Advantages of hydropower stations

- The CO_2 emissions for hydropower are very low; in fact, this is clean fuel source in air pollution compared to coal and natural gas (Steinhurst, Knight and Schultz, 2012).
- Water is the available natural resource and advantageous for any state to grow domestic economy and means of reducing imports (Department of Environmental Affairs, 2014).
- It is cheap compared to fossil fuel, as it is the natural resource (Department of Environmental Affairs, 2019).
- Water from the power plant can be re-used in the ecosystem (Department of Environmental Affairs, 2019).
- Hydropower plant can be a quick backup when load shedding because they rapidly reach maximum power output (Maehlum, 2019).
- The diverted water to hydropower plants helps to prevent flooding, assist in irrigation of plants and ensure continuous ecosystem in dams (Department of Environmental Affairs, 2019).

3.7.4.2 Disadvantages of hydropower stations

- Water flow disruption has the down-stream impact to plants, animal and community that is dependent on the flow of that water (Department of Environmental Affairs, 2019).
- Dam disruptions erodes plantations downstream and at times, people crossing down-stream dies due to water flooding when disruptions happen (Department of Environmental Affairs, 2019).

3.7.5. Investment in Gas Power Stations

International Energy Agency (2018) reported USA as the main producer of gas and China being the biggest consumer. Department of Environmental Affairs (2019), supported by International Energy Forum (IEF) and Organization of the Petroleum Exporting Countries (OPEC) on the 07 November 2018, reported the moderate growth rate (22%) of gas worldwide, as mostly by Asia due to renewable energy. The Minister of Department of Energy, Mammaloko Kubayi, has supported the construction of 3700MW gas power plant in South Africa in order to create the sustainable energy mix that is clean and efficient for socio-economic development (Dall'omo, 2017).

There are seven gas power plants in South Africa. The most prominent is Coega Development in Port Elizabeth, Eastern Cape, South Africa, with an investment portfolio of R151 billion that has created more than 100 000 jobs (Brand South Africa reporter, 2015). Kubayi (2017) cited by Dall'omo, (2017) continued stating "South Africa's natural gas industry could boost gross domestic product by R250 billion by 2030; and create up to 328 000".

3.7.5.1 Advantages of gas power station

- They are small meaning that they require smaller space for power plant construction compared to other technologies (Stephen, 2015)
- They weigh less, meaning minimum haulage requirements toward installation and low cost to run (Brand South Africa reporter, 2015).
- They are easy to install and start operation, where 600MW CCGT can start generating within 18 months (Dall'omo, 2017).
- International Energy Agency (2018) further stated that could use both gaseous and liquid fuel (including synthetic fuel.
- According to United Nations Framework Convention on Climate Change (UNFCCC) (2019), gas has lower environmental restrictions compared to nuclear power stations.
- According to World Energy Outlook (WEO) (2018), they use less water compared to steam turbines.

3.7.5.2 Disadvantages of gas power station

- They need the compressor to start the engine and the compressor makes a high noise (International Energy Agency, 2018).

- The output efficiency of the turbine is low since two-thirds of the generator is used to drive the compressor (International Energy Agency, 2018).
- It is most likely going to be depleted in the future, so its availability is time bound (International Energy Agency, 2018).
- It attracts violence and terrorism as it is the case in the Middle East and in other African countries (Rezazadeh, Talarico, Reniers, Cozzani & Zhang, 2018).
- There is disagreement regarding its cleanliness, as there are experts believing that gas emits CO_2, for example, the case in China, where the Greenhouse Gas (GHG) emissions reduction not according to initially anticipated (Yang, Wu, He, Li, Han, Wang and Wu, 2016).

3.7.6 Investment in Landfill Gas

Tortosa (2017) described landfill gas power plants as consisting of approximately 50% methane, 42% carbon dioxide, 7% nitrogen and 1% oxygen compounds. Landfill gas is a readily available, local and renewable energy source that offsets the need for non-renewable resources such as oil, coal and gas (International Energy Agency, 2018).

The formation of the gas happened through the decomposition of plants and animals to form methane and carbon dioxide gas (Scheutz & Kjeldsen, 2019). They continued stating that methane and CO_2 vents to the atmosphere and circulate like all other gaseous exchanges, to the surrounding environmental species. Meng (2015) stated that it is part of the environmental management that these gases have to be extracted from the landfill, as it may present the unpleasant smell. The unpleasant smell may kill the plantations nearby or may lead to explosion hazard. The extraction of these gases from the atmosphere, flared or burned is to produce electricity or heat (Rees-White, Mønster, Beaven, and Scheutz, 2018).

3.7.6.1 What are the advantages of landfill technology?

- The waste that cannot be recycled can be useful for the benefit of community in producing energy (Scheutz & Kjeldsen, 2019).
- The landfill also become the player of ecosystem because wild life are also dependent on it (Scheutz and Kjeldsen, 2019).

3.7.6.2 What are the disadvantages of landfill technology?

- There is limited space for the landfill waste (Rees-White et al., 2018).
- From a business point of view, waste management companies have to pay heavy taxes to put waste into landfill (Scheutz & Kjeldsen, 2019).
- Methane emission leads to global warming (Rees-White et al., 2018).

3.7.7. Investment on Nuclear Power Stations

International Atomic Energy Agency (IAEA) and World Nuclear Association on the 22 February 2019 stated that South Africa has one Nuclear Power Plant (NPP) station in Western Cape called Koeberg, consisting of two 970 MW units making the total installed capacity of 1940 MW. This NPP is the aging 33 years old Pressurized Water Reactors (PWR), which have taken severe aging strain resulting into unplanned shutdown for inspection, maintenance, tripping or at times re-fueling (Van Wyk, 2013).

There has been number of protests regarding further nuclear infrastructure developments (Fig, 2017). These protests are related to nuclear safety, as the results of Fukushima nuclear power station incident in Japan on the 11 March 2011 (Van Wyk, 2011). Germany has shut down its nuclear power plants but experienced an increase in global warming thereafter (Cilliers, 2018). Brown (2016) stated that there are worldwide anti-nuclear protests. According to Head (2018), the reason why Former Minister of Finance was dismissed was that he refused to sign the nuclear deal that was going to cost South Africa the capital budget of R1.2 trillion. Cilliers (2018) stated that the organizations that are against nuclear development have looked at this as the constraining budget for developing state, another point of concern was safety related to nuclear.

South African government has another nuclear site in Pelindaba in North West province in South Africa, where Pebble Bed Modular Reactor (PBMR) is situated (Eskom, 2019b). Ellis (2018) stated that this PBMR facility is within the premises of National Engineering Council of South Africa (NECSA). He continued stating that the establishment of this was to produce PBMR fuel for commercial purpose highly focusing on both domestic and global markets outside African countries. Further to that he stated that there was no anchor country that committed on the purchasing contractual agreement; therefore, it was discontinued in 2010 after the expenditure of almost R10 billion with almost R8.8 billion paid by government of South Africa.

3.7.7.1 Advantages of nuclear technology

- Nuclear power has very low CO_2 emissions compared to most power plant technologies (International Atomic Energy Agency (IAEA), 2018).
- The power plant can last longer than that of coal power plant or gas (World Nuclear Association, 2018).
- It requires small space compared to other technologies (Nucnet, 2018).
- The uranium cost is 20% to that of the entire power generation and it uses less energy, such that one tennis ball size coated particle a 60kW bulb can burn for 12 hours for 16 years (Ellis, 2018).
- The nuclear power plant will have the ability to generate electricity for almost 90% of the time, this ensure reliability on the nuclear power plant as the reliable source of energy (Nucnet, 2018)
- It is independent of natural ecology such as wind that is dependent of wind currents and solar that is dependent on the sun (World Nuclear Association (WNA), 2018).

3.7.7.2 Disadvantages of nuclear technology

- Dong (2016) reported that the accident in one power station leads to number of people dying, the example of Fukushima in Japan, 2011 and Chernobyl in Ukraine in 1986 reported between 600 000 to 800 000 people died, 116 000 people evacuated to at least 30km away and 565 people that were diagnosed were diagnosed with thyroid cancer. Both these accidents rated level seven on International Nuclear Event Scale (INES).
- It is not the widely known subject therefore, very few skills and capabilities of dealing with nuclear available compared to other power plant technologies (Nucnet, 2018).
- It is costly to build compared to other technologies, as it is an estimate of R1 trillion is required as the capital outlay for South Africa's proposed development (Sonnekus, 2016).
- It requires international safety standards, such that when there is a leak, the international nuclear agencies have to be involved in mitigating the situation (World Nuclear Association, 2018).
- There are many related safety compliance requirements such as mining, transportation, waste management and operation requirements (Nucnet, 2018).
- It is difficult and it take years to manage the nuclear waste radioactivity and risks (World Nuclear Association, 2018).
- The world has stockpile of uranium that is much more than that of coal (Lam, 2011).

3.8 COMPARATIVE ANALYSIS OF POWER-INFRASTRUCTURE DEVELOPMENT TO WATER AND ROADS INFRASTRUCTURE

The complexities caused by solar and wind energy availability demands non-reliance to them for base load supply (Ntusi, 2018). Further to that, Ntusi (2018) continued stating that coal fired power plants cannot be switched-off timeously due to procedural requirements. Partridge (2018) argued that excess wind power generation creates surplus energy generated as coal power plant generates constantly. Ntusi (2018) further described that additional energy coming from solar and wind leads to unscheduled dispatching of power to other countries. Gourdo, Fatnassi, Tiskatine, Wifaya, Aharoune and Bouirden (2019) stated that this is because solar and wind energy are still having the storability challenge.

The research has revealed 50% of South Africa population will be living in urban areas by 2035 (Deloitte, 2017). The National Development Plan of South Africa (2019) has declare that there is a demand for development of related infrastructure such as roads, water and electricity in order to grow the economy. It starts by presenting the problem statement stating that the congestion in urban South African roads and roads connecting to neighboring countries is concerning and continued to state that lighting for roads leading to towns and connecting major cities requires revision for future road expansion.

Zuma (2017), the former President of South Africa, on the State of the Nation Address (SONA) in 2017, electricity infrastructure requires prioritization in South Africa but further highlighted that water is the priority. The Minister of Finance, Malusi Gigaba in the 2018 budget speech stated that electricity and roads infrastructure are the major priorities.

South Africa has nine hydroelectric power stations (Eskom 2019), investing in water infrastructure correlates with security of electricity supply. South Africa is facing the unavailability of water as one of the challenges. The Minister of Water and Sanitation, Nomvula Nonkonyane in 2016 stated that Kwa-Zulu Natal mostly in the North of Durban was water shedding. Further to that, the South African provinces called Western and Eastern Cape in 2017/18 faced severe water shortages.

Portafaix (2018) supported by Iny (2017) stated that water shedding brought the new dawn of life in their livelihood. The agricultural sector was severely impacted, which is the primary feed to landfilled sites for electricity generation, and the prices of food increased (Nonkonyane, 2016). Gigaba (2018) continued stating that South Africans had to face the food increase, water shortages and increase in electricity prices. The then Deputy President of South Africa, Cyril Ramaphosa (now President), had numerous negotiations with Lesotho Government for water supply in South Africa. Simms (2017) stated that this required an estimated of $8 billion (World Bank, 2019) of capital infrastructure investment,

such as pumps and electricity supplying that infrastructure. Trading economics, 2019, which is the indicator assessing how consumers of each country perceived administration for the next 12 months reported that consumer confidence have improved from that of Former President Jacob Zuma. This means that tax collection is more likely to improve for better power-infrastructure investment (Gaffney, 2016).

Ramaphosa (2019) addressed the South African nation by mentioning unbundling of Eskom. The economic growth prospection by unbundling Eskom will increase unemployment rate current at 27.1% (NUM, 2019). Zungu (2018) stated that many South African people have attempted to start their own businesses but were liquidated. Nattrass (2014) stated that the prevalence is bribery; preferential sourcing and corruption have been among the reasons discouraging pursuance. Most of those that have attempted to venture into business were unable to withstand financial demands (Greenwood, 2019). He continued stating that there is a lack in business related skills such as administration, cash-flow injections, supply chain and business contract understanding, adherence and management including instituting penalties. Zungu (2018) stated that these emerging entrepreneurs revert to having a boss for low wage income due to inability to pay for water and electricity expenses and other operational expenses. African countries have the world lowest wage payment rates and detrimental labour exploitation (Isaac, 2018). In some African countries such as Zimbabwe, Mozambique, Sudan have no income tax at all (Morisset & Cunningham, 2015). South African income tax and Value Added Tax (VAT) system is at the same rank as the developed countries such as China. The income tax of China is 45% just like South Africa and VAT for China is 16% whilst South Africa is 15% (Ploumen, 2015).

3.9 THE IMPACT OF TAX ON CAPITAL POWER-INFRASTRACTURE INVESTMENT

Morisset and Cunningham (2015) believed that governments of the world are able to raise domestic revenue. Ali, Fjeldstad and Sjursen, (2014) stated that these governments are able to reduce dependence from foreign aids and they are able to fund infrastructure development through tax collection. Tax collection is the global challenge, but Sub-Saharan countries are leading in terms of non-payment (World Bank, 2015).

Morisset and Cunningham (2015) believed that globally, tax collection is such that salaried employees are paying 90% of tax, farmers paying 60%, self-employed pay 40% and politicians pay 10%. The study conducted by Morisset and Cunningham (2015) between East African Community (EAC) countries such as Kenya, Tanzania, Uganda and South Africa, supported by Ali et al. (2014) revealed that South

Africa has a high tax to GDP ratio. Morisset and Cunningham (2015) conducted a similar study and had similar findings but concluded that the difference between the developed countries and developing countries lies in their ability to collect tax (refer to Figure 3.19 below). According to World Bank (2015), South Africa has better tax collection and enforcement system than compared to Kenya, Tanzania and Uganda meaning that South Africa is a greater opportunity in attracting Foreign Direct Investments (FDI) compared to Kenya, Tanzania and Uganda. These countries have enhanced tax compliance through their tax reform programs and improved revenue administration (Ali et al. 2014).

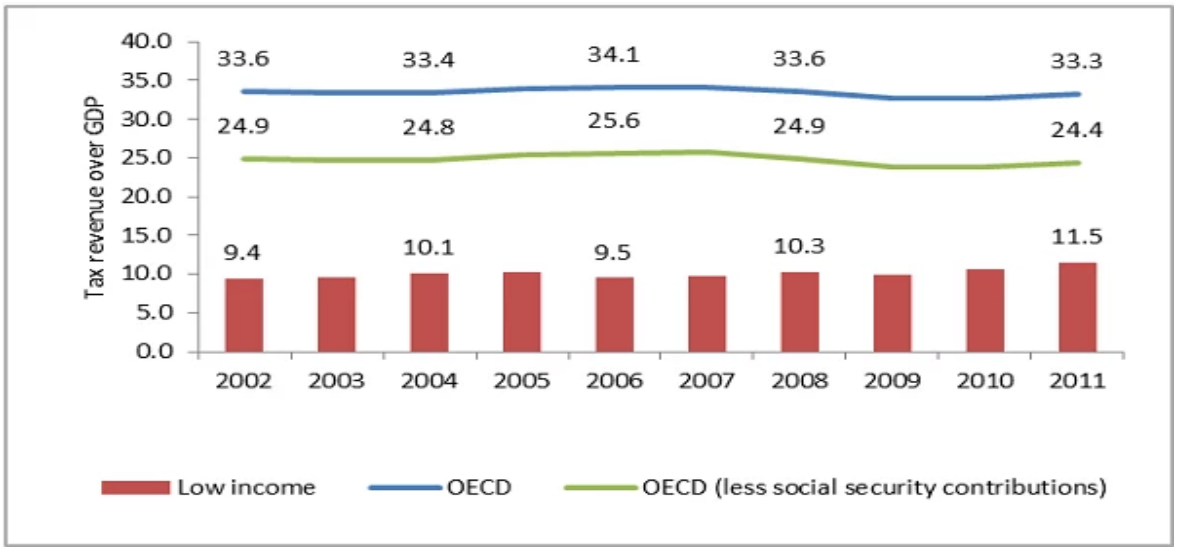
Braithwaite (2017) stated that the reason people avoid paying tax is influenced by factors such as cost benefits analysis of paying tax. Wenzel (2018) stated that some people are not really seeing the fiscal benefit from government regarding tax payment. Gaffney (2016) stated that there is a lack of trust between the taxpayers and government authorities due to corruption. Hlongwane (2016) stated that some government authorities see themselves as agents that deserve tax exemptions.

Investments requires an understanding of a country's fiscal policy, market condition and be certain about political stability status before doing investments (Laopodis, 2013). Isaac (2018) stated that developing countries more particularly South Africa has low wage but high tax to reduce. He continued stating that South Africa raises tax so that USA foreign investors would have confidence in their ability to raise more capital and regarded as credit worthy for loans, as they will be able to pay for their own debts. The USA Senate continued stating that when these developing countries reduce on their taxes, they will have an opportunity to focus on their future and develop infrastructure that will grow their economy.

Hlongwane (2016), advisory on Africa Tax system, and Gaffney (2016), who is the Associate Director for Tax in KPMG, stated that 65% of tax collection in Africa is coming from Personal Income Tax (PIC). They continued stating that the challenge in tax collection is the tax evasion by successful business corporates wanting to invest their money outside South Africa without following proper processes. Gaffney (2016) further emphasized that taxpayers want to pay tax that is fair, appropriate for the benefit of the society but will avoid even evade when realizing that tax that they have paid benefits the individuals instead of the society.

The World Bank then conducted the study for tax collection between the Organization for Economic Corporation and Development (OECD), which is 36 countries of non-African membership working cooperatively with other developing countries such as Asia, China and Brazil. The results substantiated by Gaffney's (2016) presentation, stating that Africa is worst in tax collection compared to other developing countries with low income. This is depicted in the following Figure 3.19.

Figure 3.19: Tax collection difference between developed and developing countries



Source: World Bank, 2015

Figure 3.19 presents the analysis of tax collection between countries that are of OECD and low-income countries including South Africa. Besley (2014) stated that developing countries described as collecting low-income tax with ability to collect 12% of tax whilst the developed countries are collecting average 33% to 40% of tax. Karimia, Kaliappana, Ismaila and Hamzah (2016) stated that in the low-income countries, tax collection is failing to withstand demands for low-income countries.

Ongwamuhana (2011) conducted the study in Tanzania and found that the untaxed trading such as non-stock items and informal sector trading contributes to 43% of GDP. IMF country's report (2016) state that restructuring tax would have improved Tanzania revenue income to that of other East African Countries (EAC) as they collected less than for 2016. Dar es Salam with the GDP of 30%, is paying 90% of Tanzania's tax from telecommunication, beverages and cigarettes (Ongwamuhana, 2011).

South Africa is also facing the tax collection challenge (South African Receiver of Revenue (SARS), 2018). Ungureanu and Dascălu (2017) believed that tax evasion is the global challenge that every state should develop innovative ways of collecting tax from individuals, corporates, employed people, farmers, politicians and so forth. Kleinbard (2015) stated that tax assists in funding each country's infrastructural development programs. Fabbri (2015) stated that countries such as China, Japan and Europe went to the extent linking tax to lottery. He continued stating that when buying, the seller gives buyer the lottery receipt, in this way, government is able to link the sales from the seller and the customer has the chance of playing lottery.

Bruno (2019) described the fight against tax evasion as the global challenge. Ploumen (2015), the Dutch Minister for Foreign Trade and Development Cooperation, highlighted how developing African

countries should reform their tax system if they want to increase tax revenues in a more transparent way in order to withstand fiscal demand for Sustainable for Development Goals (SDG) and Millennium Development Goals (MDG). Shaxson (2015) highlighted that Multinational Enterprises (MNEs) have made developing countries to lose up to USD $300 billion by taking advantage of tax treaties, by re-investing in offshore investments and tax exemptions.

According to Cronje (2018), in February 2018, the Former Minister of Finance in South Africa, Malusi Gigaba, increased VAT from 14% to 15% to increase revenue collection by R36 billion for the financial year of 2018/2019 which is equivalent to USD $2.8 billion (using exchange rate of R13 to the US dollar). The division of USD $300 billion by USD $2.8 (R36 billion) equates to almost 107 countries using linear distribution. According to the African Union (2020), there are 54 African countries. The linear distribution of USD $300 billion in 54 countries would mean each country would receive just more than USD $5.5 billion (R72 billion). Otusanya (2011) acknowledges the role of MNEs but argues that their tax evasions and avoidance compromises government revenue income, and infrastructural development.

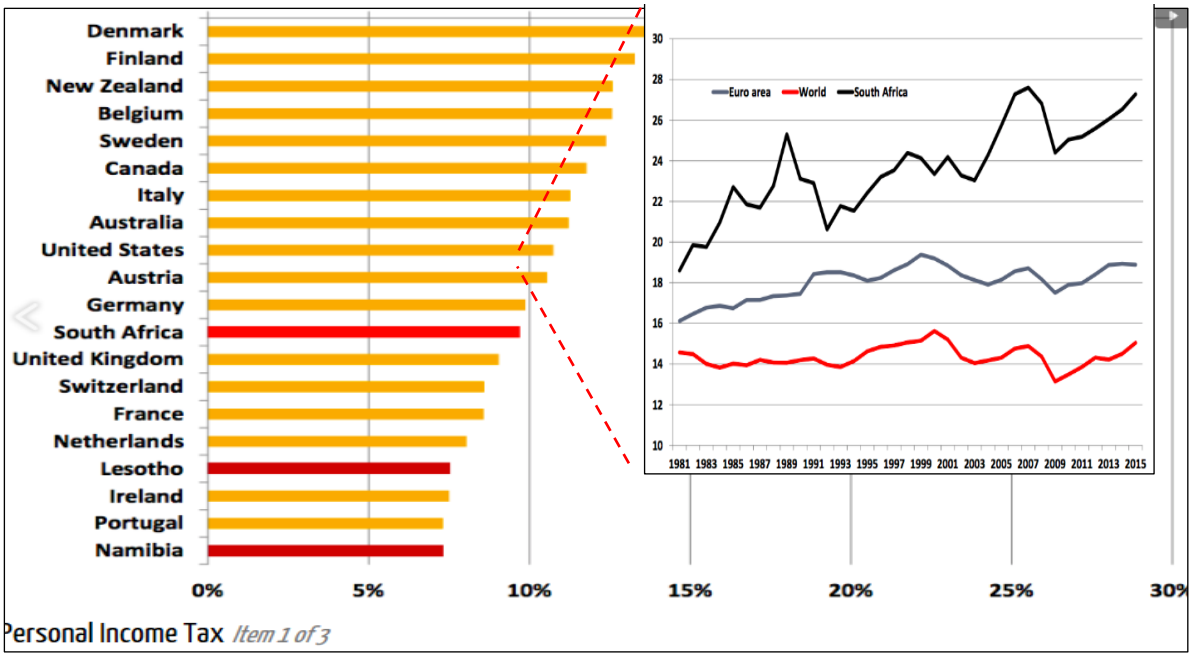
For developing countries to strengthen tax collection, they need to forgo tax exemption, improve the capacity of tax inspectors, and restructure income and wealth tax (Ploumen, 2015). Collection of tax through consumption such as Value Added Tax (VAT), is a burden for poor people. Bhorat and Tarp (2016) identified six countries with the fastest growing economies as Ethiopia, Mozambique, Nigeria, Kenya, Ghana and South Africa. The review on MNEs by Omar and Zolkaflil (2015) revealed that despite global growing interest in African trade, there is very limited empirical data available to support the relationship between the economic growth and employment.

McCullough (2017) explained that employment in Sub-Saharan Africa is mostly in agriculture, mining and SMMEs as in the case of South Africa. Sow (2017) further stated that some of these workers are not receiving wages regularly. The Foresight Africa (2017) described Africa as where employment will be in the next 2030, as the above-mentioned six developing economies mentioned on the previous paragraph will change the economy of African continent. Auriol and Walters (2012) stated that there would be growth in the number of employees that are reaching the taxable bracket.

They continued stating that tax restructuring will lower tax paid by individual taxpayers, this will mean that electricity consumers, who are taxpayers, will have better affordability to pay for their monthly bills. The tax comparison for developing African countries including South Africa is compared to the developed countries on Figure 3.20. If developing countries including South Africa, can institute tax

reform, the revenue income will improve thus reducing the budgetary constraints of funding power-infrastructure development projects (Auriol & Walters, 2012).

Figure 3.20: Personal Income Tax in South Africa compared to developed countries



Source: Writer, 2018

Evident from Figure 3.20 is that, Writer (2018) presented that South Africa is the 12th highest Personal Income Tax (PIT) country in the world. South Africa ranked 32 in world GDP per capita, has the PIT, which is even higher than developed countries such as Netherlands, France, Ireland and Switzerland, but below countries such as Germany, Canada and USA. The further reviews on South Africa's tax and GDP discovered that it is the world's seventh highest tax charging country with 27% charge (refer to smaller graph in Figure 3.20). According to Writer (2018), this will drive people into poverty.

In the next section, the study consolidates what the higher tariffs than inflation means for poor South Africans in terms of capital power-infrastructure investment. There is also a high personal income tax on low labour wages, higher tax for GDP, low business confidence, relaxed tax treaties leading multinational companies evading USD $300 billion tax by getting tax exemption and reinvestment in offshore assets, and increased in VAT from 14% to 15% in order to increase tax revenue income of 2018/2019.

3.10 WHY ARE SOUTH AFRICANS PAYING SO MUCH TAX?

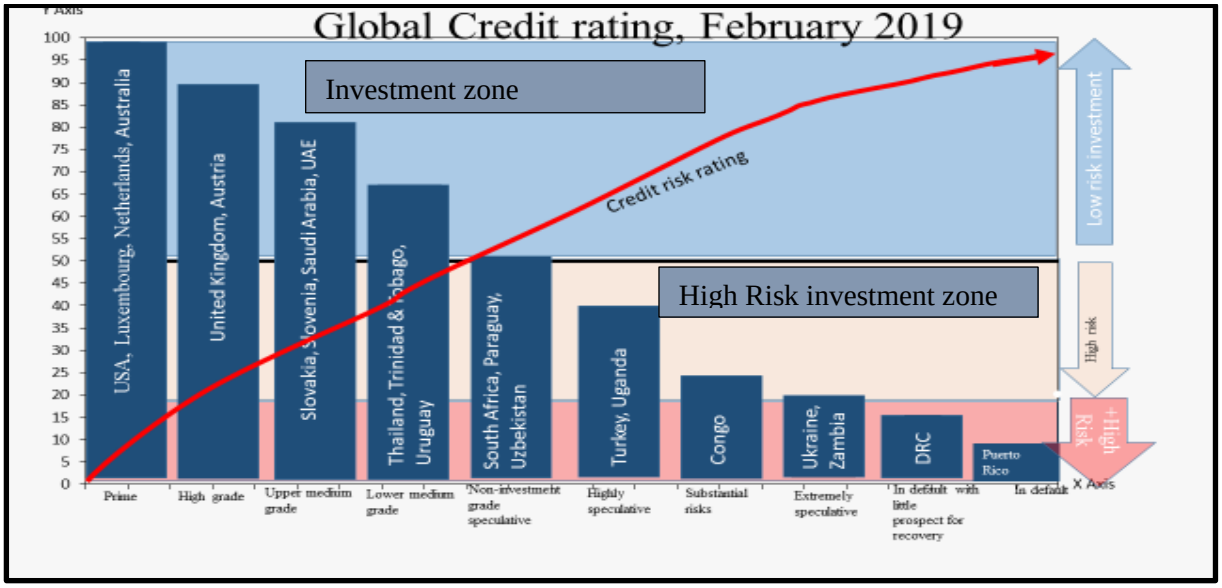
South Africa as the non-oil exporting country is the leading borrower of money, goods and services from external investors (Central Intelligence Agency 2017). Dupont (2017) supported by IMF (2018) presented G7 countries after the suspension of Russia, as countries that are having more than 50.1% of global GDP. There are two critical causalities for high tax payment. Ploumen (2015) described the first as high national debt to ordinary citizens as leading to increase on tax for repayment. Borrowing money for power-infrastructure development means an increase in fiscal demand (Auriol and Walters, 2012). The second causality is financial security uncertainties (Lyons, Grable and Joo, 2018). Investors invest after in-depth consideration for the possibility that the money may not be returned (Annamalai, 2013).

In addition to that, the demand for infrastructure investments has complexities unlike corporate investments. United Nations Conference on Trade and Development (UNCTAD) (2016) indicated that their mandate is to integrate countries into world economics through investments. Some countries require investors to corporate funding whilst some are for infrastructure investments (Annamalai, 2013).

Ballester and González-Urteaga (2017) reviewed the credit rating agencies to fund investments in developing economies, described credit rating for each country or the utility as dependent on certainties.

According to Trading Economics (2019), the international rating agencies such as Standard and Poor, Moody's and Fitch ratings have last rated South Africa as positive in 2004 and 2007. In the following Figure 3.21 depicts the international credit rating meaning and its impact will be deliberated thereafter.

Figure 3.21: The global credit rating with an intention of showing South Africa



Source: Investopedia, 2019

Figure 3.21 illustrates the country's credit rating done by various international credit rating agencies. On the Y-axis, is the credit rating starting from zero to 100. The Trading Economics (2019) explained that zero rating means high risk and 100 means riskless. On the X-axis are the descriptions of risk rating starting from Prime (on the left) to in default (on the right). Prime being the best rating status and in default below the level of measurable junk status (Trading Economics, 2019). The red is an indication of the risk credit line meaning that countries in prime credit rating status are low risk.

Trading Economics (2019) and also referring from figure 3.21, the risk rating is in zones, as depicted in the form of different color zones. The blue zone above 50 up to 100 is the zone for investment and the purple zone below 50 to 20 is the high-risk zone (coloring done for demonstrative purpose, information gathered from TE and World Development Indicators). The red zone is an extreme high-risk zone for that is recommending no investment. In figure 3.21, countries rated 100 such as USA, Luxembourg, Netherlands and Australia are considered riskless, Prime or high-grade rating AAA+ (Trading Economics, 2019). Countries such as Ukraine, Zambia, DRC and Puerto Rico are countries that have extreme high risk, and not recommended for investment (Mykhayliv & Zauner, 2017). South Africa has a credit rating of BB, which is below investment zone, meaning that it has investment uncertainties (Trading Economics, 2019). This means that when the government of South Africa borrows money, South Africans will pay more compared to the people in countries with Prime credit status such as USA, Netherlands, Luxembourg and Australia or people in high grade credit status countries such as United Kingdom, and Australia, for the equal value on money borrowed (Cai, Gan & Kim, 2018).

3.11 WHAT IMPACT DOES COUNTRY'S OVER INDEBTEDNESS MEANS ON CURRENT AND FUTURE CAPITAL POWER-INFRASTRUCTURE INVESTMENTS BY POWER UTILITIES?

South Africa is a developing country with international credit rating 50 (BB+), meaning no investment recommended, as stated in section 3.10 (Trading Economics, 2019). In order to develop power-infrastructure, South African government or power utilities has to borrow money from international investors (Kastratovic, 2019). Drautzburg and Uhlig (2015) explained that infrastructure development is considered as a government-spending stimulus. In South Africa, development of capital power-infrastructure is done through the release of Integrated Resource Plan (IRP) (Radebe, 2018), after proper consultation with relevant stakeholders.

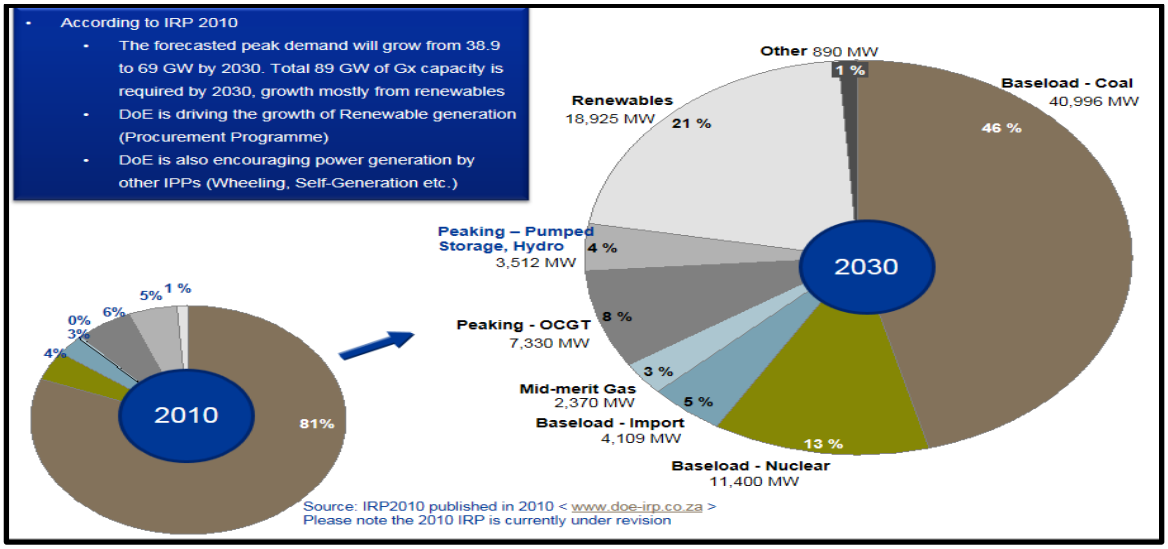
Radebe (2018) further stated that the plan has to talk to the current and future plans for development of power-infrastructure in South Africa. In the previous IRP 2010, a proper description has been emphasized that power utilities have an obligation for power-infrastructure development and provision of security of supply, as this is the anchor for South Africa's economic growth. The Integrated Resource Plan (IRP) (2010) as promulgated by Department of Energy (2010) presented the power-infrastructure investment plan with the forecast of up to 2030.

Council for Scientific and Industrial Research (CSIR), (2017) presented the draft IRP 2018 modelled to demonstrates an increase in electricity demand in 2030 and 2050. The capital borrowing for development of Renewable Energy Independent Power Producers (REIPPs), more in particular for solar and wind was capital intensive during the promulgation of IRP, 2010. When IRP 2010 was promulgated, the power-plant fleet efficiency, mostly coal power plants, was 81% (CSIR, 2017) (refer to Figure 3.22, the small Pie chart on the left). South African government opted to pay carbon tax, which is the tax paid for carbon emissions on coal-fired power stations (Yelland, 2015).

In March 2019, the Minister of Energy, Jeff Radebe has promised to release the promulgated IRP, 2018/19 (Radebe, 2018). The expectation was that the IRP 2018 would demand an increase in power-infrastructure development for the 2030 and 2050 forecast (CSIR, 2017 supported by Department of Energy, 2016/17). The draft IRP (2018) released for comments depicted an increase in electricity demand until year 2030 and 2050 horizon, as it was expected (refer to Figure 3.22 and Figure 3.24 below).

In the following figure 3.22, this study presents the difference between promulgated IRP 2010 power-infrastructure, up to 2030 and it further presents the difference with power-infrastructure requirement to 2050 in Figure 3.22 and Figure 3.23.

Figure 3.22: Adjusted National Energy Planning of South Africa in 2030



Source: Eskom National Energy Planning, 2018

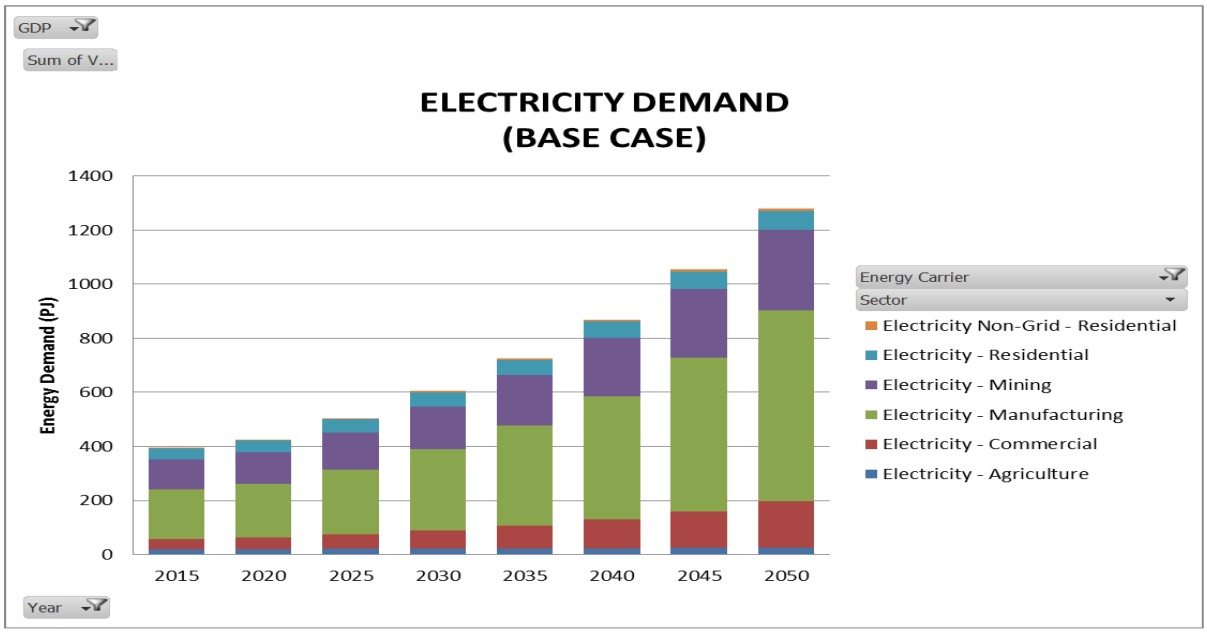
The above Figure 3.22 illustrates that in the year 2010, coal as the traditional electricity generating technology in South Africa had the baseload supply capacity of 81%. In the 2030 graph, coal is expected to reduce to 46%. It is expected that nuclear will increase from 4% in 2010 to 13% in 2030. This modelling was through plans to source 9600MW plan to start construction in 2018 (World Nuclear Association, 2018). Referring to Figure 3.22, the renewable energy will increase from 1% in 2010 to 21% in 2030. The increase in renewable energy was as the results of the planned bid 4 of IPPs planned to be signed for R65million (Department of Energy, 2016).

According to the Power Global Data (2018), renewable energy is the world leading capital investment. Its trend manifest in South Africa as well in terms of capital investment generating technologies (Department of Energy, 2016). Referring to Figure 3.22, renewable energy is followed by plans to increase nuclear as stated above, then OCGT generating technologies increases from 6% to 8% before 2030 (Department of Energy, 2018). Peaking hydro-pump storage is expected to reduce from 5% to 4% in 2030.

Electricity in South Africa continues to be the demanding commodity from all sectors (Hadebe, 2018). He continued stating that it is for the reason the IRP is aimed to provide guidance of how the country should position itself to withstand economic growth trajectories. Department of Energy in 2016

modelled all electricity demanding sectors to determine what could be the future electricity demand in 2050. Figure 3.23 below presents the simulation.

Figure 3.23 Indicating electricity demand by sector in South Africa



Source: Department of Energy, 2016

In the above Figure 3.23, the forecast indicates that the manufacturing sector is going to demand more electricity by 2050. In 2050, the manufacturing sector alone forecasted to demand electricity that is more than all sectors combined in 2030. Mining and commercial sectors are the other two sectors that will need more electricity in 2050. The demand for electricity in one sector, such as manufacturing, by 2050 will be equal to the estimated total national demand forecasted to be in 2030 (Department of Energy, draft IRP, 2018). That means that South Africa has to raise capital to build this power-infrastructure through borrowing (Drautzburg and Uhlig, 2015; Ploumen, 2015).

Baharumshah, Soon and Lau (2017) described the approval of fiscal based on national debt to GDP ratio. As stated earlier that South Africa is a developing country, Tran (2018) described developing countries as susceptible to capital flow. Eberhardt and Presbitero (2015) described countries with low GDP growth as high risk for long-term financial investments.

Drautzburg and Uhlig (2015) argued that developing countries continue to accumulate debt, which is serviced through high interest rates and high tax increase adjustments. This means that for South Africa to meet their electricity demand, South Africa has to borrow money that will be recovered through tariff

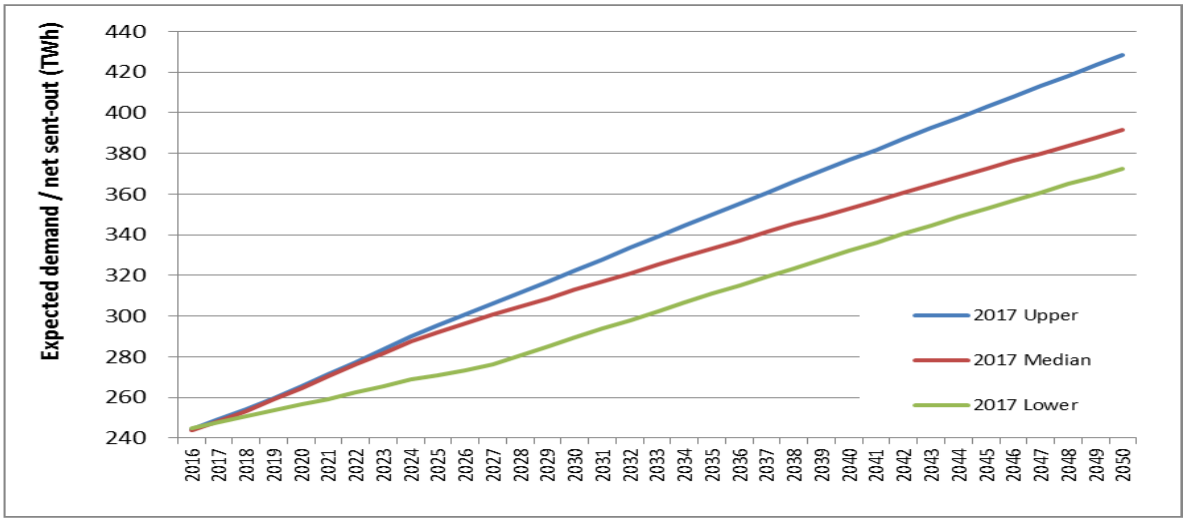
increase and an increase in tax (Drautzburg and Uhlig, 2015; Ploumen, 2015; Baharumshah et al., 2017; Tran, 2018).

De Moor, Luitel, Sercu, and Vanp (2018) raised another argument of subjectivity in credit rating approval as inclusive of trading intensity with USA, trading proximity, the dominated religion in the borrowing country and common language used in that country. This means that countries that were previously colonized by non-English speaking colonies are susceptible to high sovereign risk premiums (De Moor et al., 2018; Ploumen, 2015). South Africa was colonized by European, Dutch East India Company in Cape Town Table Bay after the arrival of Jan van Riebeek in 1652 and in 1806 South Africa was colonized by British (This is the General knowledge, no reference to give).

The narrative raised by De Moor, Luitel, Sercu, and Vanp (2018), De Moor et al., (2018) and Ploumen (2015), places South Africa at a trading proximity disadvantage but in contrary creates better advantage due to being an English speaking country and mostly Christian religion compared Mozambique (colonized by Portugal) and United Arab Emirates (UAE).

Summarily; countries with high GDP, low inflation, high income per capita, low debt to export ratio, never have transactional default history and high level of employment through industrialization, previously colonized by English speaking country like USA, Britain, close proximity to USA, trade intensity with USA and religious Christianity are getting better sovereign credit rating with low premium repayment risks. South Africa does not meet all the USA low interest rates minimum requirements whilst the demand for capital power-infrastructure investment as described in draft IRP 2018 is intensive with high GDP growth projections. There are three considered projections as depicted in Figure 3.24 with economic growth trajectories until 2050.

Figure 3.24: Electricity Demand Growth Forecast until 2050



Source: Department of Energy, 2018

In the Figure 3.24, the three lines represents the GDP growth projection and relative assumptions of electricity demand growth. Department of Energy (2018) explained that these three lines were developed using historical quantitative patters and relationships. The GDP forecast growth rate was analyzed together with relative forecasted annual electricity demand.

The upper forecast (blue line) assumed linear economic progression with the forecasted annual GDP growth rate of 3.18%. The electricity demand is forecasted to grow by 2% by 2030 and decline to 1.66% by 2050. The median (red line) forecasts the aggressive changes economic in GDP growth to 4.26%. In this situation, the electricity demand will drop significantly to the demand of 1.8% by 2030 and 1.4% by 2050. The green line represents the lower projection of GDP growth 1.33% by 2030 and 1.21% by 2050. The lower GDP assumes an increase in electricity intensity before dropping.

Summarily, Figure 3.24 represents forecasted electricity demand not GDP growth projections. Furthermore, its conceptualization is that an increase in GDP may results in a decrease in electricity demand as consumers will improve energy efficiency or switch to other energy technologies such as solar rooftops, floor heating using hot water and Small Modular Reactors (SMRs). In contrary, if the GDP remains unchanged, the demand for electricity will increase. When GDP is low, investments in alternative electricity demand will initially increase but due to trading complexities, the electricity demand will progressively decline.

However, considering Figure 3.23, if the manufacturing sector alone can increase its electricity demand by 2050 to be equivalent to the total national demand in 2030, it means the South African government will require more capital investment for infrastructure development in order to withstand power-infrastructure demand requirements (Tran, 2015). Pollet et al. (2015) reviewed South Africa's position regarding the challenge towards meeting the capital power-infrastructure investment. Eberhardt and Presbitero (2015) describe this challenge as it could lead to energy challenges, aged and inadequate infrastructures, inefficient regulatory processes, lack of investor confidence and high degree of uncertainty in the long-term plans for power-infrastructure investment requirements. South Africa is characterized by low economic growth compared to United Kingdom (UK) and Brazil. The comparison in 2014 and 2019 is that South Africa was 1.8%, UK was 2.6% and Brazil was 0.5%. In 2019, these countries were 0.2%, 1.5% and 1.1% respectively (Statistics of South Africa, 2019)

The following section discusses the mechanisms developed through literature regarding power utilities of South Africa. The ranking of electricity payment in South Africa is as expensive as among some of the developed countries (Refer to Figure 3.20). In the following section are some of the reasons why South Africans are paying high tax rates, has national debts but still failing to withstand it projected futurist electricity demand.

3.12 THE NEED FOR INFRASTRUCTURE DEVELOPMENT VERSUS PROCUREMENT REFORMATION TO DEVELOPED COUNTRIES, BEST PRACTICES

Pal, Wang and Liang (2017) stated that infrastructure development in all countries requires capital investment, which is achieved through debt from investing institutions or equities from investors. According to World Bank Group (2019), globally, construction contributes more revenue to the GDP compared to other sectors. The complexity with procurement is that it is the most non-complying industries to Supply Chain Management (SCM) best practices (Shojaei and Haeri, 2019). South African power utilities are among countries with the procurement system where consultants do power-infrastructure design and the contractors do the construction. They continued stating that the consultant becomes accountable for procurement procedural best practice compliance, but the contractor's commitment will have very limited procurement risks (Shojaei and Haeri, 2019).

Picha, Tomek and Löwitt (2015) stated that the best practice is to assign Engineering, Procurement and Construction (EPC) activities to the contractor instead of the consultant. The reformation of the procurement traditional practice in South African power utilities requires an understanding of procurement macro-economic benefits (Deloitte, 2015). Zhou, Tang and Lan (2018) stated that the changes of the supply-chain management policies to include Total Point of Assumption (TPA), as the risk sharing as part of cost savings projections are currently incomprehensible by the practitioners in most parastatals in South Africa.

In 2015, Deloitte, the international consulting company, conducted the study in Australia regarding infrastructure projects. Deloitte reported non-compliance to procurement and practices. According to Deloitte (2015), Australian government spent USD $43 billion per annum on infrastructure construction projects however due to procurement delays, USD $239 million could had been reported as savings had procurement practices were initially complied with. Furthermore, they stated that USD $87 million of USD $239 million spent on revision of designs whilst construction was in progress, of which USD $5 billion could have been saved between 2015 and 2030. Ansar et al. (2016) supporting the statements made by Deloitte (2015) stated that more could have been saved should proper procurement was followed. Following on this discussion, Shojaei and Haeri (2019) described poor procurement as among the causes avoidable over-investment but its effects leads to an increase in asset value, financial liquidity and destabilizes the trend of economic growth.

Kodongo and Ojah (2016) studying the public infrastructure development and economic growth, concluded that it is not every infrastructure that is being developed that contributes to economic growth.

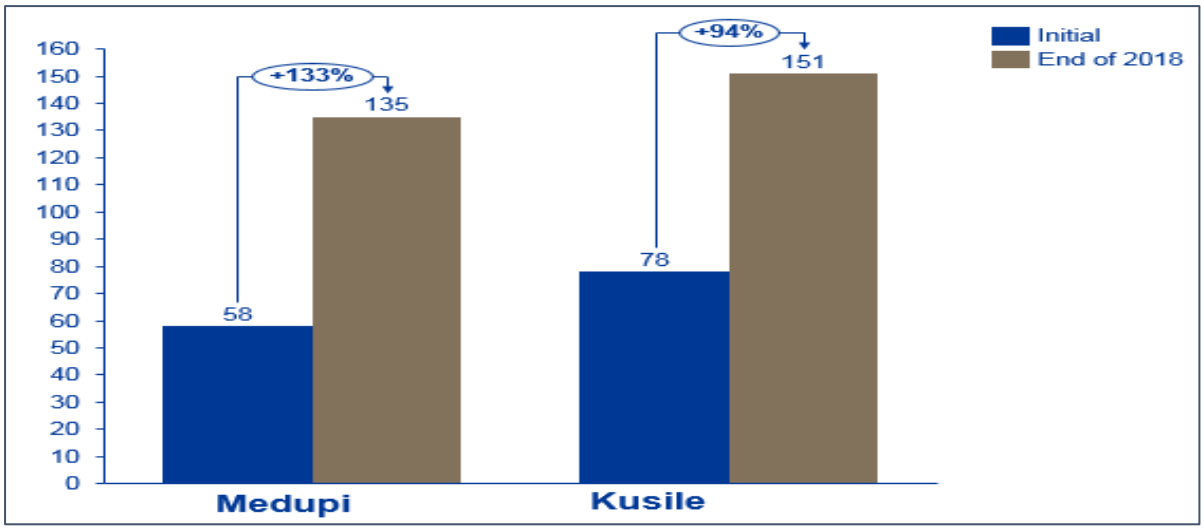
As Eikeland (2015) explained that, it is the myth that mega-infrastructure investment tends to create more employment opportunities compared to the country with limited investments in infrastructure development. The challenge is to combat corruption (Nevin, 2017, Salling and Leleur, 2015). In reviewing the causal factors, leading to improper procurement process of goods and/or services included the following:

- Improper definition of the project deliverable required (Deloitte, 2015).
- The mechanism of delivery, including the related skills required (Nevin, 2017).
- Improper conducting of the bidding process and documentation required (Shojaei and Haeri, 2019).
- Inability to provide certainty guarantees pertaining to scope tendered for (Saguin, 2018).
- Improper risks management strategies during project when in execution (Shojaei and Haeri, 2019).

South Africa is currently facing a cost overrun on its mega-infrastructure projects such as Medupi and Kusile, but nothing compared to what China is facing (Valentine, 2014). Eskom (2017) on the Corporate Plan for 2016/17 to 2020/2021 reported that these projects have escalated costs more than what was the initial approved budget. Li, Hubacek and Siu (2012) reviewed cost escalation reasons in China as the reflection for cost escalation of power-infrastructure in South Africa. The review of cost incurred by Eskom in the construction of Medupi, Kusile and Ingula, concurs that procurement of foreign goods or services have the direct impact of high cost escalation. In the case of South Africa, it requires that the Department of National Treasury have to borrow more money, with high interest rates

The impact of Eskom cost escalation has been depicted in the following Figure 3.25. In this figure, the costs incurred were as reported in Eskom financial reports that ended on the 31 March 2017. It is however imperative to be explicit that such cost escalations become the input process for tariff increase negotiation with NERSA through MYPD and RCA.

Figure 3.25: Cost to completion uncertainties for Medupi and Kusile, the unit of measure is in billion rand (R, bn)



Source: Eskom, 2017

Figure 3.25 indicates that Medupi that started in May 2007 at R58bn and was estimated at R135bn for the financial year 16/17 and estimated at R145bn by July 2017 (Barradas, 2017) and these costs excludes capitalized borrowing. In Figure 3.25, Medupi at Execution Release Approval (ERA) stage, its deliverables are as detailed in Figure 3.27 on page 90. Medupi was approved for R135bn from the initial ERA cost of R58 bn. This shows an increase of R77bn, 133% increase from the initial approved budget.

It is the same scenario in Kusile on the right-hand side of the Figure 3.25 above. The initial ERA approval cost was R78bn and at the end of 2016/2017 was at R151bn. This is an increase of R73bn, 93.5%, from the original approved budget. The investments and synchronization of certain units together independent power producers into commercial operation has made Eskom to have surplus capacity 3800MW to put on cold reserves by 2020 (Njobeni, 2017).

Both power stations incurred an increase of R150bn (Eskom, 2018). Assuming that both power stations had proper basis of estimation done, the power utility would had been saved from liquidity crisis that led to its employees protesting that led to load shedding in 2018 (Monyei & Adewumi, 2018). In 2018, South Africa had surplus capacity, the Energy Availability Factor (EAF) had improved and the status of energy security had stabilized (Phasiwe, 2018). Three questions are pertinent to ask:

- **What is South Africa doing with surplus capacity?**

  In answering that question, the study has to answer who advised on excessive power-infrastructure investment in South Africa. There are various reasons but the main reasons are reduction of carbon

emissions and secondly the scramble for the Africa as financial investment market by emerging developers (Schwerhoff & Sy (2017); Scholvin (2015); Oji, Soumonni & Ojah, (2016)).

Power et al. (2016) argued that the development of energy infrastructure between South Africa and Mozambique through BRICS is to create energy capacity in order to be able to exploit Africa' resources. Scholvin (2015) stated that emerging developers are scrambling for Africa as an investment market. Power et al. (2016) believe that this scramble is the strategic intent of colonizing Africa through power purchasing agreement.

Baker (2015) argued against the notion of colonizing Africa by emphasizing that power demand is for creation of security of supply in Africa in order to realize sustainable economic growth. Schwerhoff and Sy (2017) supported Baker (2017) by stating that African countries have to support each other, as they all need investors for their economic growth and sustainability. Kazadi et al. (2016) emphasized that developing countries are very cautious about strategies of colonization.

This makes the argument raised by Power et al. (2016) to lack political economic facts. Ouedraogo (2017) and Trotter, McManus and Maconachie (2017) have indicated that surplus capacity in Africa is required in order to address carbon emission and to create sustainable economic growth. When surplus capacity is available and dispatched to other countries, it facilitates the intentions of African Union, New Partnership in Africa Development (NEPAD) and Programmes for Infrastructural Development of Africa (PIDA).

- **Is South Africa exporting surplus capacity to other countries?**

In Chapter 3, Section 3.7, it was mentioned Eskom supply 45% of Africa's market. According to SAPP (2018), Eskom has surplus capacity in excess of 7000MW since 2017. Eskom (2019, with tag esk191) defined this as insufficient as the international norm is to have 15% of the installed capacity. There is no literature or knowledge proven that African power utilities are taking advantage of the available surplus generated power capacity. According to Ntusi (2018), South Africa import unscheduled available surplus energy to other African countries. Ward and Staffelli (2018) defined the challenge for most of South African power utilities including municipalities that they do not have storage capacity for excessive power generated either scheduled or unscheduled for utilization when there is less generation (Ntusi (2018) also supported this statement). Coal-fired power stations experience peak generational demand during the morning and afternoons (Eskom, 2019).

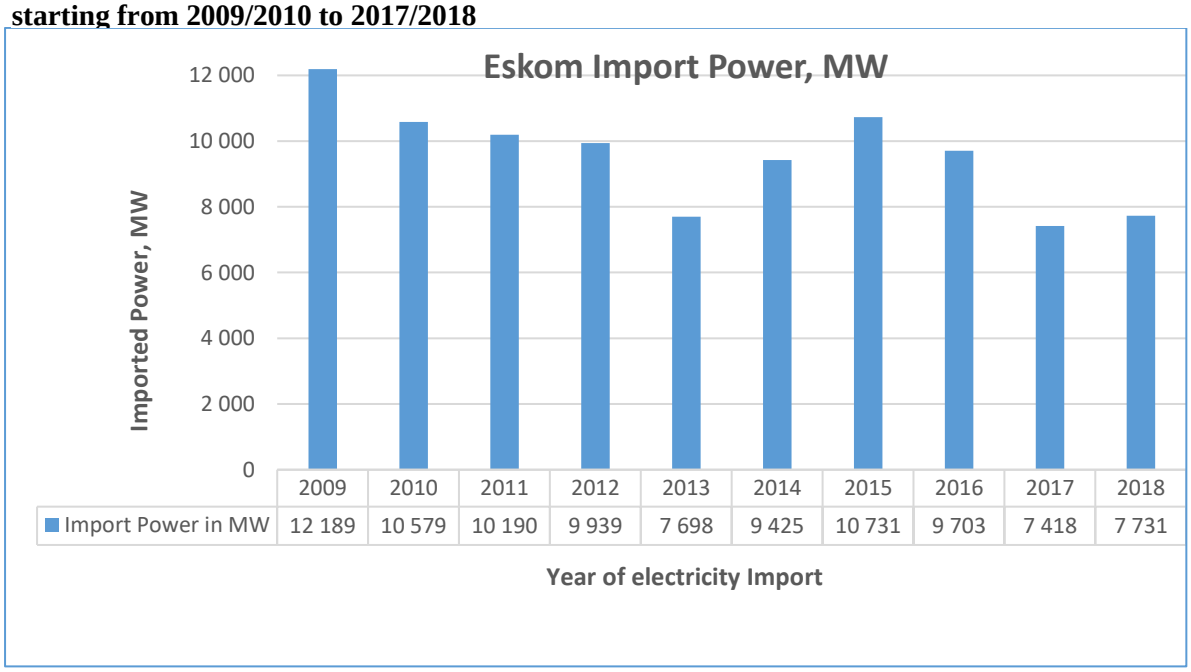
Either municipalities or any other power utility, if they had sufficient storage capacity such as using batteries or capacitors (Bhowmik, Chandak, & Rout, 2018) could have stored the surplus or excessive power generated during the day or at any time within a 24 hours period. According to Writer (2019), there is no any other evidence for the construction of energy storage facility, other than the loan of R6 billion to Eskom by New Development Bank to build 360MW of battery storage system in 90 sites in the Western Cape, Northern Cape, Eastern Cape, and KwaZulu-Natal.

Montoya, Garcés and Serra (2018) detailed how batteries can be utilized for energy generation and how capacitors can be used to store energy and how Voltage Source Converters (VSC) can convert energy from DC back to AC in case it has to be re-connected to the grid. In this case, the municipalities can be able to store electricity using batteries and supply back to the grid for the benefit of their own business or co-generation for reselling back to Eskom.

- **Why then South Africa is still reporting an increase in importing electricity?**

In many sections of this Chapter 3, discussions related to power import resurfaced. Eskom importation of electricity was higher than forecasted starting from 2015 (Eskom, 2018). Eskom Financial statement 2017/2018 revealed an increase in imports of electricity compared to 2016/2017 as represented in the following Figure 3.26

Figure 3.26: The Import Power from SADC countries starting from Financial Year End (FYE) starting from 2009/2010 to 2017/2018



Source: Eskom, 2018

In the above Figure 3.26 in the FYE of 2017, Eskom reported the reduction of imported power from SADC countries mostly being Mozambique. Unit 4 in Medupi was synchronised to the grid on the 31 May 2017 (South African Government News Agency, 2017). Kusile unit 1 was synchronised in March 2017 (Eskom, 2017), and improved plant availability factor from 69.9% in 2015 to 77.3% by the end of March 2017 (Eskom, 2017). Why then there is still electricity import for the 2017/2018, if there is a surplus capacity and IPPs are generating to the grid with some unscheduled dispatching to foreign African countries?

3.13 THE CAPITAL INVESTMENT PROCESS

Hu, Harmsen, Crijns-Graus and Worrel (2018) described investment in power-infrastructure as capital intensive with high cost of capital. They continued stating that power generation has sunk costs, with stochastic downward revenue income risks. Project Management Body of Knowledge (2013) described Monte Carlo simulation as a tool for the realization of probabilities. Hu et al. (2018) recommended complementary case analysis model more than Monte Carlo Simulation. They further stated that complementary case simulation gives understanding of investment barriers, risk, uncertainties and ignorance. This then provides more certainty in terms of the investment process (World Bank, 2018).

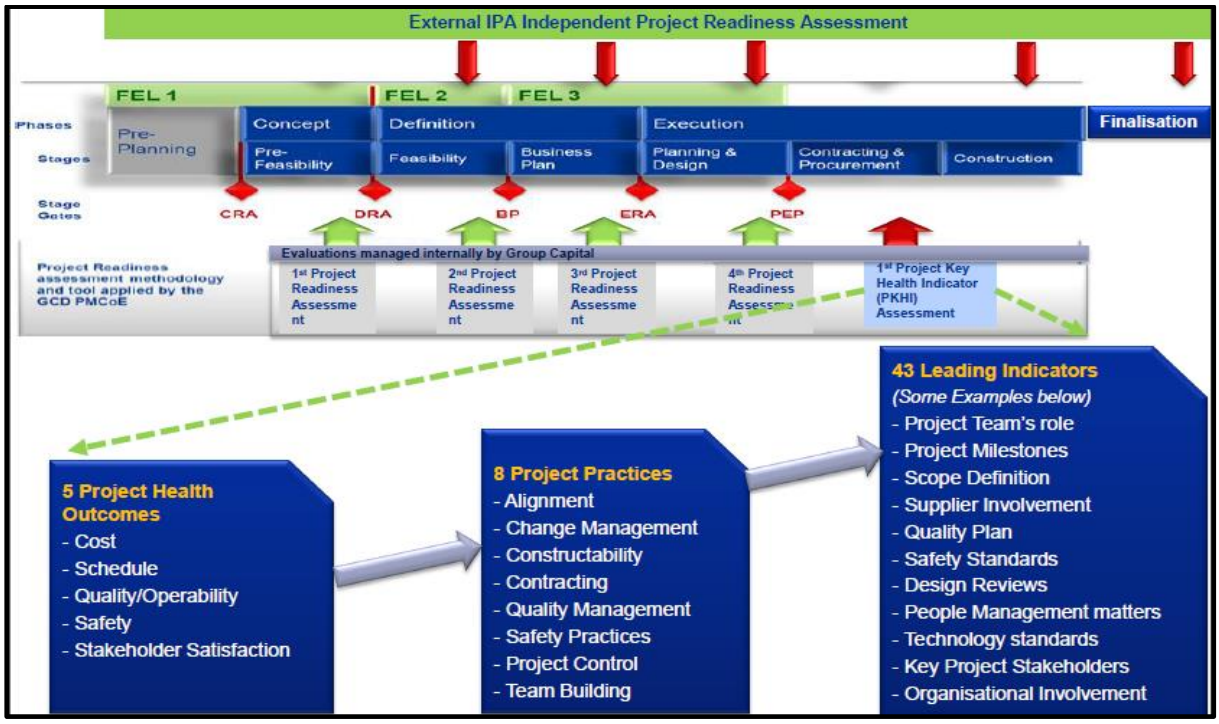
Soenksen and Yazdi (2017) described investment requirements as stage gate decision-making process. Wuest, Schmidt, Wei and Romero (2018) alluded that stage gates creates communal understanding of the investment content. In power utilities, stage stages are unable to reduce stochastic probabilities of cost overrun (Power et al., 2016). The model for capital investment process may be institutionalized but adopt uniformity for stage-gate reviews (Underhay, 2018). In this study, the review of other State-owned entity such as Transnet and Association for Municipalities with Electricity Undertaking (AMEU) revealed that the capital investment process aligns to that presented in Figure 3.27. Noring (2019) described this process as Public Asset Corporation, used by most state-owned entities.

The vertical integrated structure of power utilities in South Africa derived uniformity of investment process (Baleni, 2018; Magubane, 2018). The process demands the transparent procedure of budgeting, allocating, prioritizing and controlling the assigned capital to described deliverables (National Treasury, 2019). In compliance with Public Finance Management Act and Municipal Finance Management Act, the National Treasury mandated public entities to ensure that investment approvals go through decision-making bodies (Source).

Mellichamp (2017) described the investment decision-making process as inclusive of opportunity creation that has to be cautioned through stage gates. Santandrea, Sironi, Grassi and Giorgino (2017)

continued describing the pertinence of assessing and monitoring financial indicators such as Return on Investment (ROI), Net Present Value (NPV), and Internal Rate of Return (IRR). These indicators have to present the reality of possible investment benefits to be realized (Dhavale and Sarkis, 2018). The capital investment process presented in Figure 3.27 has no traceability matrix of the previous investments made in the same asset to reduce capital constraints.

Figure 3.27: Indicating the capital investment process within Eskom



Source: Underhay, 2018

Figure 3.27 is an extended life cycle of the project because it includes work that is undertaken before governance committee approves the project, in order to release budget and sign the project charter, and it ends after the benefits of deliverables have been realized. In the above Figure 3.27, there are acronyms used to define the stage of approval required and they are explained in the following Figure 3.28.

Figure 3.28: Definition of acronyms used in previous Figure 3.27

ACRONYM	DEFINITION
CRA	Concept release approval.
DRA	Design release approval
ERA	Execution release approval
HOA	Handover approval
FRA	Finalization release approval

There is an explanation of each deliverable in each stage gate but what is imperative is that the governance committee approves or disapprove the movement of the investment (project) from each stage gate to the next such as from CRA to DRA (National Treasury, 2019). This process applies to all capital investment projects for state-owned companies in South Africa (Noring, 2019). However, it is noted that there are different wordings used such as Transnet uses Front End Loading (FELn), with the *n* representing number 1 to number 4 (Transnet, 2016).

The approval of investments in this process is influenced by financial projections that makes the investment either viable for approval or not (Soenksen &Yazdi, 2017). In South Africa, due to coal-fired power stations, Eskom contributes more than 50% of CO_2 emissions (International Energy Agency, 2019; World Nuclear Association, 2019). The Integrated Resource Plan (IRP) presents the national strategy of meeting the growing electricity demand whilst reducing the greenhouse gas emissions from more than 50% to below 34% by 2030 (Department of Energy, 2010).

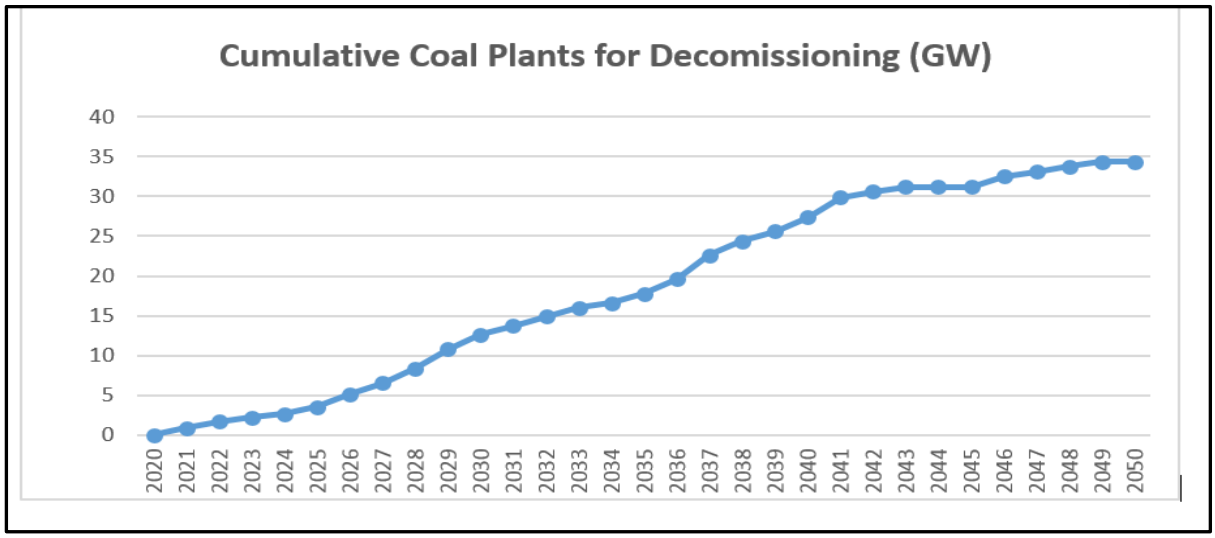
On the continent, South Africa contributes more than 50% of CO_2 emission (Bah & Azam, 2017). South Africa's Electricity Distributors including the state-owned power utility, Eskom, are facing the severe decline in the capital investment with almost 50 of coal-fired power plants are coming to the end of life before 2030 (refer to Figure 3.29 below) and has to be replaced with either another coal fired power plants or different technology. There are 25 that will need replacement by 2040 and 12 by 2050. The commitment of South Africa to reduce carbon emissions is demanding immediate actions with technology that has less carbon emissions (Ramaphosa, 2019).

Hu et al. (2018) described that the investment on renewable energies is capital intensive. This may threaten business stability leading to certain business to liquidity, as NERSA also approved 13.82% for 2019/20 tariff increase (Creamer, 2019). Investment in a more capital-intensive technology with a high

level of uncertainty is designing national poverty (Auriol & Walters, 2012; Mykhayliv & Zauner, 2017; Writer, 2018)

The capital investment process should be as such that it protects both the consumer and power utility from possible exploitation (Deloitte, 2015; Shojaei & Haeri, 2019). These challenges are continuously increasing as Figure 3.29 depicts the number of the power plants to be replaced. It must be noted that most of these are coal fired power plants that are emitting greenhouse gas (Eskom, 2018).

Figure 3.29: Eskom coal power plants to be decommissioned starting from 2050



Source: Department of Energy, 2018

In Figure 3.29 above, looking at graph, it is estimated that approximately 13 coal-fired units will demand replacement by 2030, estimated to cost R3.5bn (Van den Berg, 2013). Bohlmann, Bohlmann, Inglesi-Lotzand Van Heerden (2016) described projections of energy demand aligning to Department of Energy economic growth trajectories on 2013 IRP, by stating that the required installed capacity will increase from 44000 MW in 2011 to 53297 in 2019. They continued stating that the blackouts that started in 2008 led to the business revenue loss amounted to R300 billion. EIUG (2019) stated that load shedding and 10% forceful reduction in power consumption affected their business as they consume 40% of South African electricity.

The lifespan of Kusile and Medupi power stations is 50 years, meaning that the planning for their replacement should start long before 2040 (Eskom, 2015). Eskom is facing a decline in sales revenue and applied for a tariff increase year on year to recover R66 billion as part of its MYPD4 (Corporate plan 2017-2021). Mboweni (2019), stated that the government bailout of R23bn for the next three years

is for operational cost. The demand for capital budget to address power stations coming to an end of their life spans and demand expansion on transmission lines remained unanswered (Govender, 2018).

Writer (2019) reported loses as the results of corruption to be in the region of R500 billion, with the cost to completion of R334 billion and the debt deficit of R420 billion. Tandwa (2018) citing Zizi Kodwa who is the spokesperson of the ANC stated that the removal of some of Eskom Executives alleged to have been involved in the corrupt dealings is in line with re-installing the credibility of the state-owned companies.

Transmission Development Plan forecasted more than 72000 MW of the installed capacity requirement by 2028 with the forecast that renewable technology will replace coal-fired power plants (Majola, 2018). Cilliers (2018) described South Africa as the country with strong protesters against nuclear power stations, such as in Germany. The abundance of coal-reserves regardless of its high CO_2 emissions, has made South African power consumers to ignore the fact that nuclear technology is healthier than coal (Monyei & Adewumi, 2017 supported by Nakumuryango & Inglesi-Lots, 2016). South Africa's power utility Eskom has Koeberg as its nuclear power station based in Cape Town (Eskom corporate plan, 2016/17 to 2020/21). Nuclear has lowest CO_2 emissions, however for the fact Japan nuclear power station, Fukushima, failed in 2011, resulted in the number of people dying, has made some of the South African consumers to be repulsive to nuclear technology.

3.14 CONCLUSION

This chapter presented that there are 188 licensed electricity distributors in South Africa, and they are all facing decline in revenue income whilst they have a backlog in investing in aging infrastructure. The chapter further presented that the cost per kwh in South Africa's bid is 80c/kwh for wind and solar compared to Mexico, Chile and Abu Dhabi with an average of 25c per kwh. CSP reported at R2.02 per kWh (800% more than 25c per kWh) with the CSP plant being developed in Northern Cape.

The chapter further indicated that all these 188 licensed electricity distributors including the state-owned utility, Eskom, are using the project life-circle model recommended for investment and governance purpose. This model does not consider environmental difficulty factors, stakeholder divergent expectations leading the schedule overrun and increase in project costing, this compromises macro-investment strategic objective. The cost to completion on power-infrastructure doubles the initial estimates.

South Africa has energy mix dominated by aging coal fired power plants due for replacement. Capital investment in power-infrastructure has consistently declined in licensed electricity distributors in South

Africa. The future of South Africa is to disinvest in coal-fired power plants and replace them with renewable energy. The indicators if the company is likely to face financial bankruptcy revealed as including the increase in electricity demand whist there is limited investment for capacity creating and maintenance, increase importation of electricity from neighboring countries. The revenue cash flow for retailing is dependent on the availability of exported commodities. If the exporter fails to meet recipient's power demand, there will be rolling blackouts.

The chapter also indicated that if the size of the company is too big the resources output becomes less than their potential production capacity. The chapter further indicated that advancement of the company towards meeting global standard such as by investing in the latest renewable energy technologies whilst unable to recover revenue are among causes leading to poor capital status. Further to that, the chapter indicated that the impact of ineffective management of technical and non-technical losses.

This included curbing tariff increase for distribution and transmission sectors whilst there are unregulated price increases for primary energy, such as coal cost in generation section. The chapter also indicated that policy makers are not vigilant and lack innovation towards profitable restructuring of power utilities, as they always lead the company to be "too big" which leads to collapse. The chapter further indicated that power utilities have not invested in the energy storage capacity, as the results due to volatility nature of wind and sun, when there is surplus capacity that they can dispatch unscheduled to neighboring countries. These countries could sell it on their own.

The chapter further stated that there is no substantive evidence that capital power-infrastructure investment causes the economy to growth. The chapter further indicated that an increase in electricity consumption does not mean that there is economic growth. In fact, the chapter presented the possibility the reduction in electricity consumption could be related to the technology used, which consumes very low. Contrary to that, the chapter found that investing to high priority infrastructure projects boost the economy.

Rich democratic countries have done measure investments but since all investments are in debts, the country end up with high debts, increases tariffs for service delivery and increased tax burden. There was an indication in this chapter that rich economies invest in construction projects assuming that they will generate better GDP and better employment opportunities. The presentation made in this chapter was that most of these projects fail to generate returns initially forecasted. There is a contradicting literature that suggest that mega-infrastructure investment do not leads to economic growth. The study of China being the developed country, but have low Energy Availability Factor (EAF)

Chapter 4 is going to present the research methodology and procedure using literature guide from writers such as Neuman, Creswell and others. It will further present the population of the study, location and how data will be collected, administered, verified and presented in Chapter 5.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter provides basic important elements of the research design process used in this research project. To that extent, research design, research methodology, and data collection techniques are discussed. Furthermore, there is a discussion related to the issues of reliability and validity. The chapter concludes by indicating that this project observed the required ethical considerations and examples of such considerations are given.

4.2 RESEARCH DESIGN

Neumann (2014) supported by Creswell (2014) and Denzin and Lincoln (2018) by describing research design as comprising of research methodology, data collection, data presentation and analysis. In other words, research design provides an insight on how the entire research project was conducted whereas research methodology is the approach used in conducting the research project. To clarify this point Schindler (2019) describe research design as including "consideration of the research approach, which is to be taken, and the research methods, data collection tools, and the methods of data analysis that are to be used". Furthermore, Denzin and Lincoln (2018) indicate that research design includes a "pilot study" which amongst other things is used to test whether or not the research instruments used are valid and reliable. In the light of this broad description of the research design, this chapter provides an insight amongst other things on the research methodology used, data collection techniques, piloting of the research instrument, and how data was analyzed.

4.3 RESEARCH METHODOLOGY

In view of the fact that the study requires addressing complex matters pertaining to the challenges that power utilities are currently facing in South Africa, the study demanded thorough considerations of data gathering. The consideration of certain prominent authors such as Neuman (2011, Neuman (2014), Kumar (2014) and Creswell (2014) was important. The work of these authors provided the study of this project information that was important in deciding which methodology was appropriate for this study. The research instrument(s) could provide the best information possible given the constraints of the study.

According to Neuman (2011), Nuemann (2014), Kumar (2014), Creswell (2014) and Creswell (2018), the purpose of any research project could be either exploratory, explanatory, descriptive or causal:

- **Exploratory designs**: This is when the study is examining a new area unknown in the area or discipline being investigated. The study then forms the basis for the future research. This study has to make sure that there is a base information to conduct the second research in that field. It is very common or mostly preferred that the study utilizes the qualitative data analysis because of its definitiveness and flexibility. In such a study, the investigative skills are required to derive outcomes that are organized. Exploratory designs are often used by marketers when, for example, they are launching a new product and they want to determine whether it is well received by the customers.

- **Descriptive designs:** This refers to interrogating into issues, situation or causal effects that some such as Sekaran and Bougie (2016), view it as more of a descriptive approach of social phenomena such as who, which, how principles. There is a strong assumption from Rose, Spinks and Canhoto (2015) that descriptive and exploratory research can be effectively applied and produce appreciable outcomes sequentially. Creswell (2014) assumed that using descriptive approach, the accurate well-defined subject can be realized such as to say 60% of World Presidents goes to church less than 5 times a year. The exploratory approach can follow to ascertain why 60% of World Presidents goes to church less than 5 times a year.

- **Explanatory designs:** This refers to the ability to explain certain social behaviours. In this case, beliefs and conditions are easily explained through the theories and reasoning. Explanatory designs provide reasons why, for example, a certain belief, trend, perceptions occur. Using the above example, explanatory research could be used to find out why the World Presidents go to church less than 5 times a year.

- **Causal designs:** This refers to the type of design that seeks to determine cause and effect between phenomena. For example, the study could be interested in finding out what causes female students to pass mathematics more than their male counterparts in a grade 12 of a particular school. In experiments, for example, the study may be interested in finding out what happens if one group is subjected to a treatment and another is not.

Looking at the dynamics of this research project, the study employs an exploratory design because there is no evidence of the use of systems thinking in assessing capital power-infrastructure investment within power utilities and in Eskom in particular. In the case, where there could be any systems thinking applied in capital power-infrastructure investments, it will not be applied in the similar manner in which

it is envisaged in this study. To a certain extent the research employs some elements of causal design because the study was interested in determining what caused or influenced the current dire situation that South African power utilizes are faced with. In addition to the above categories, seasoned researchers such as Neuman (2011), Neuman (2014), Kumar (2014) and Creswell (2014), and Brynard, Hannekom and Brynard (2014), agree that whilst the study may fall under the above categories there are essentially four types of research designs namely case study research, ethnography, action research, and survey research.

- **Case study** research is that research which studies the phenomenon on its setting. The study focuses on a specific phenomenon or entity or case.

- **Ethnography** involves studying the phenomenon by participating in the culture of the phenomenon being studied. In other words, the study was conducted whilst immersed in the culture of the phenomenon being studied. For example, if the study wants to research street kids, the researcher may participate as a street kid and learn their behaviour from within.

- **Survey research** is the most common research and is conducted mainly using questionnaires, to determine the beliefs, opinions, preferences of the participants about different phenomena.

- **Action research** is the type of research, which is aimed at effecting a particular desired outcome. It is the research that is a response to an identified problem, a desired outcome is known, and the duty of the researcher is to obtain information that could be used to construct ways and means of effecting the desired outcome.

It could be argued that this is some form of an action research because the desired outcome is known, and the study simply wanted to find ways and means of achieving this outcome but using systems thinking.

4.4 RESEARCH METHODS

Authors such as Neuman (2014), Kumar (2014) and Creswell (2014) are of the view that there are three types of research methods namely qualitative, quantitative, and mixed research methods. Each of these three methods is briefly discussed below and an indication is then provided, which one the researcher in this project deemed appropriate.

4.4.1 Qualitative research methodology

Creswell (2014) describes qualitative methodology as the methodology that requires data collection mostly by conducting interviews or by obtaining it from texts. Furthermore, Creswell (2014) describes qualitative methodology as a method that allows the participants to respond in a flexible, often subjective, manner. Authors such Brynard, Hanekom and Brynard (2014) and Schutt (2012) state that qualitative studies or research approaches are characterized by a small number of participants and in which interviews are often used. In may be noted that a qualitative study can be done in other ways other than through interviews, for example, qualitative data may be collected through observation like in the case of ethnographic studies. Furthermore, qualitative studies can be conducted as field studies. Field studies require researchers to collect the data from the participants' natural environments. Furthermore, the researcher interacts face to face with the participants and the basis of data collection is on topical discussion. This requires a lot of acclimatization to various personalities and ground-rule setting of the participants (Creswell, 2014).

4.4.2 Quantitative research methodology

The quantitative method involves quantifying the collected data in numbers, graphs or formulas (Sekaran & Bougie, 2016). In some cases, as argued by Rose et al. (2015) in support of Creswell (2014), the researcher needs to present the hypothesis and test it based on certain variables in order to be able to report in a format that indicate how many felt in a particular way. The hypothesis may drive or lead to certain experiments that may determine the certain outcome or create other sets of theories.

Furthermore, Creswell (2014) argued that quantitative research methodology might be used to test objective theories by examining the relationship among variables. This is done by using numeric statistical values such as in the case of correlations where the researcher may be interested in determining whether there is any co-relation between phenomena or variables. In most cases, quantitative data is collected using the questionnaire and analyzed using the Survey Monkey (Saunders, Lewis and Thornhill, 2014).

The collection of data and the logical interpretation of questions by the respondents requires further regression analysis (Creswell and Creswell, 2017). The presentation of the regression analysis will be immediately after quantitative analysis in Chapter 5.

4.4.3 Mixed research methodology

Creswell (2014) described this method as hybrid method between quantitative and qualitative approaches. This methodology has been dominant in the social science research and has raised multiple presentations between constructivists and positivists in the field of social research (Brynard et al. (2014). The constructivists' theories believe that learning is acquired progressively through interaction based on the foundational experiences that influenced individuals (McLeod, 2019) whilst the positivists theories are the philosophical beliefs that regardless of changes that may be experienced but the fundamental principles and facts remain the same (Pham, 2018). In this study, the application of both constructivism and positivism became pertinent.

According to Neuman (2011), Creswell (2014) and Saunders et al. (2014), there is a no direct prescription or sequence of presenting data derived from mixed research methodology. Mixed method data is preferred when presented last after both quantitative and qualitative data has been presented (Neumann, 2014). The general agreement from all these writers is that the combination of both quantitative and qualitative data provides a better or holistic approach in addressing the research question(s) than the application of a single methodology (Creswell and Creswell, 2018; Denzin and Lincoln, 2018). In the following section, the researcher presents the selected study methodology.

4.4.4 Selected research methodology

In this study, having considered both the quantitative and qualitative research methodologies, the most appropriate research methodology for this study was mixed method. The researcher paralleled the collection of data, in other words whilst the quantitative research questionnaire was sent to the respondents, the researcher was also conducting the qualitative research interviews.

In conducting the qualitative part of this study, the researcher conducted the interviews with the engineers that are the subject matter experts, and these interviews were recorded. The permission to record the interviewees was sort from the interviewees as per University of KwaZulu-Natal's ethics policy. The qualitative data was drawn using questions that were based on five research areas that are known to be challenges in the capital power-infrastructure investment, which render all power utilities to seem substantially incapacitated to generate self-sustaining revenue income.

In line with the recommendation made by Creswell (2014), the study drew themes from the responses of the participants (interviewees) that helped to do proper data analysis. The quantitative part of the

study was used by using the same themes as in the qualitative study, but the themes were broken down into smaller closed-ended questions.

4.5 POPULATION AND SAMPLE OF THE STUDY

The population of the study comprised of 150 engineers that included project managers and other experts that are involved in the capital power-infrastructure investment process. These experts sit in governance committees such as Design Review Teams (DRTs), Resource Planning Meetings (RPM), investment (including Executive Committees, EXCO) and/or Procurement and Tender committees (PTCs). It is important to have the background understanding of the fiduciary functional output of these selected members that were selected to be part of the population and sample of the study.

The sample of the study comprised of 97 participants. Ninety of the 97 participated in the quantitative part of the study and seven participated in the qualitative part of the study. This included participants who participated in the committees mentioned below:

Design Review Team (DRT): This is the gatekeeping team of engineering stakeholders from various disciplines such as electrical, civil and environmental and so on, that look at the content of the proposals for different power-infrastructure investments. These engineering stakeholders have historical knowledge of power plants proposed for either engineering upgrade, maintenance or reconfiguration.

All engineering design modifications of the initial approval that emanate during construction complexities are sent back to this committee to review and approve changes before being constructed on site. This process is in line with engineering construction and Project Management Body of Knowledge (PMBOK). It is imperative to note that all electricity engineering designs including those for municipal electrification programs have to be approved by Eskom DRT.

Resource Planning Meeting (RPM) or Committee: This committee analyses the distribution of resources by making sure that categorization of capital requirements will be adhered to. The committee ensures that the capital investment form is completed properly, and the resource request to undertake work is adequate for executing work. This committee proposes if the work will be executed using internal resources or through the procurement of external resources.

Investment committee: This committee comprises of people discharged to conduct fiduciary obligations on behalf of Eskom or the client. They are expected to make investment decisions diligently, with loyalty, and must disclose anything that could amount to conflict of interest. They are also expected

to be astute in accounting for capital approval and expenditure on behalf of the client. The fiduciary law experts demand highest degree of integrity when performing fiduciary duties including discharging punitive measures.

Procurement and Tender Committee (PTC): This is the committee that ensures that Eskom Supply Chain Management' policies and procedures are adhered to when contracting with the external suppliers.

4.5.1 Sampling Strategy

Creswell (2014) and Denzin and Lincoln (2018), describe a sampling strategy as a technique that is used to select a sample from the population. Generally speaking, there are two categories of sampling techniques namely probability sampling and non-probability sampling. Each of the two sampling categories has different types of techniques.

Probability sampling is the sampling procedure in which there is known pre-determined chance of the element of the population being chosen to be a member of the sample of the study. On the other hand, **non-probability sampling** is the sampling procedure in which there the chance of being chosen to be part of the sample is not known**.** Kumar (2014) describes non-probability sampling as "the technique used when there is no precise quantification of the sample size". According to Neuman (2011) as supported by Denzin and Lincoln (2018), non-probability sampling is relatively cheaper than probability and is often used in qualitative data collection.

Probability sampling mainly consists of four types of sampling techniques:

- **Simple random sampling** is the sampling technique in which each member of the population has an equal chance of being chosen to be part of the sample of the study. In other words, there is a known probability of each member of the population being chosen to be part of the sample of the study. What is of particular importance, is that this sampling procedure is used when the size of the population is known. If in a class of 50 students the teacher once to choose a sample of 15 students using simple random sampling the first student has 1/50 chance of being chosen, the second student would have 1/49, the third 1/48 and so forth (Neumann, 2014).

- **Systematic random sampling** is the sampling procedure in which the researcher uses a certain system for choosing the sample of the study. For example, in a class of 50 students the teacher wants to select 15 students that would represent the class in a certain team building exercise. Using systematic random sampling the teacher can for example decide that starting from the first row in front every second student would be chosen to represent the class. Because

randomness is important, it would be important to randomly decide where to start counting otherwise the first student sitting in the front row would be automatically excluded which would be unfair. To ensure randomness the teacher can have 50 pieces of paper in which numbers from one to 50 are written on each paper and each number representing a student. The papers can then be put in a bowl and the bowl shaken. One of the students can be randomly chosen to pick one number which will be the number from which counting would start. Let us assume 7 is picked, then the student represented by 9 would be the first one to be picked, the next student would be the one represented by 11 and so forth until 15 students are selected. This way no favoritism is accommodated.

- **Stratified random sampling** is that type of sampling procedure which divides the population of the study into different strata. In this sampling procedure the members of the population are divided using a specific characteristic to ensure that sample members possessing specific characteristics are represented in the sample. This could be better explained by using an example, assume in a class of 50 students the teacher wants to select a sample of 10 students that would represent the class in a school meeting and once to be sure that both genders of the students are represented in the sample. Using stratified sampling, the teacher would first divide the class into two groups, one consisting of males and the other consisting of males. The teacher would then randomly select five female students from the group of female students and do the same with the group of male students so that in the end he has five females and five males. This way both females and males are represented in the sample. If the teacher does not do so either, he may find himself/herself selecting males only or females only or one group may be overrepresented.
- **Cluster random sampling** is the type of sampling that seeks to ensure that all geographical areas in which population members are based are considered for sampling purposes. The distinguishing feature in this sampling is the geography in which population members are based.

  Once such areas are identified, the researcher then considers residents from each of the geographical area as a cluster and select a sample that will represent the cluster. That is one stage. The next stage would be to select a number of blocks in that are from which a smaller group would be chosen. The researcher does this process with all the clusters. This could be done on a number of stages until the last group is reached from which the actual sample would be chosen to represent the entire geography.

  According to Creswell (2014) and Denzin and Lincoln (2018), non-probability sampling, mainly consist of the following types of techniques:

- **Convenience sampling** is the sampling based on the easy availability of the respondent or ability to articulate the point of view on discussion. The person chosen to be part of the sample of the study may not necessary be representative on of the entire population. The researcher may find the participants in places such as in the streets, bus stops, churches, malls or play fields. This type of sampling technique can be referred as grap sampling as it is based on the availability of the respondents.

- **Quota sampling** is the sampling technique used by the researcher to ensure that there is proportional representability in the manner in which the sample is selected. For example, if there are 60 girls and 40 boys in a class and the teacher once to choose 10 pupils to represent the class in a competition, the teacher can use quota sampling by choosing 10% of girls (6 girls) and 10% of boys (4 boys) this would ensure quota representability in the sample. It could be any other distinguishing characteristics that the researcher can use.
- **Purposive or judgmental sampling** is that sampling procedure where the researcher selects the participants specifically for a certain purpose. The chosen participant could be chosen because they possess a certain skill or characteristics in which the researcher is interested. For example, the researcher may select a group of researchers that he/she thinks have special experience and knowledge of conducting a specific research project. The researcher uses his/her judgment in selected the participants.
- **Snowball sampling** is the sampling technique whereby the sample chosen starts very small and those who are the first to participate in the study provide names of people who could possibly participate in the study. The size of the sample then increases depending on the number of referrals that the researcher gets from those who have agreed to participate in the study.

Cluster sampling was considered particularly appropriate because Eskom's operations are geographically located according to the different divisions of the power utility. For example, participants could either be from the Generation, Distribution, or Transmission component of the utility company. This sampling technique was of particular interest to the researcher but was eventually not chosen because it was not fully suitable for the research.

4.5.2 Sample and sampling technique employed

The sample of this study comprised of engineers and the sampling technique used was purposive sampling because only those engineers that are involved in capital power-infrastructure investments were selected to participate in the study. Furthermore, the researcher selected those that it was felt would have the necessary expertise and information relating to capital power-infrastructure investments.

Summarily, judgmental sampling was considered more appropriate, as engineers that are not in capital process such as design engineers and Eskom Executives such as those in Eskom College, Eskom Housing Finance and Human Resources were excluded.

4.6 DATA COLLECTION INSTRUMENTS

According to Creswell (2014) supported by Neumann (2014), there are various data collection instruments such as interviews, diaries, critical incident technique, focus groups, observations, protocol analysis technique, questionnaire.

In the quantitative part of the study, data was collected using a questionnaire and was electronically distributed to the respondents involved in the capital power-infrastructure investment process.

A focus group often comprises between five to ten participants and is administered by a moderator. In a focus group the moderator provides number of questions to be deliberated on and guides the direction the focus group is taking (Neumann, 2014 supported by Creswell, 2014). Focus group technique was considered but it would only be relevant when engineers involved in the capital investment process are in one room. In this approach, engineers would have to answer questions without having had an opportunity to engage each other. However, the researcher deemed it unnecessary to pursue focus groups as it could have compromised soliciting information from individual subject matter experts.

Observation is a technique that is applied when looking at certain behavioral patterns and quantify the number of people that behaved in that particular pattern (Schutt, 2012). Therefore, this technique was deemed not viable to produce the results that would be acceptable in the study. Amongst the reasons to reject this technique included that financial modelling, literature review, and participation in the study could not just be a matter of observation.

Protocol analysis technique is the tool used to identify skills in a particular subject. In this, concepts, attributes, values, tasks and relationships are considered (Sekaran and Bougie, 2020). At present, there is no match between this technique and objectives of this study, as this technique could compromise neutrality, leading to biasness to the intended objectives of the research output. The tasks could make participants to only focus on investments that were not handled properly. A questionnaire was considered as a possible form of collecting data. A questionnaire is often used in surveys and is convenient when the sample size is large. Questionnaires are often used in quantitative research approaches (Creswell, 2014 supported by Neumann, 2014). The second method considered was an

interview schedule, which is an instrument, used to gather qualitative data. Interviews are often used when the size of the sample is small. (Saunders et al. 2019).
In the qualitative part, the personal and telephonic interviews using the same open-ended question was conducted. The open-ended questions were sent before, the participants had ample opportunity to prepare. Responses from the participants were analyzed in line with questions of quantitative research.

4.6.1 Research instrument employed

This research project comprised two groups of participants one comprising a small number of participants and another comprising a large number of respondents. In view of the above, it was appropriate to use a questionnaire in the quantitative part of the study (See Appendix B.4) and use an interview schedule in the qualitative part of the study (See Appendix B.5).

4.6.1.1 The construction of the research instruments

The research instrument was a questionnaire created using surveymonkey.com, the internationally accepted research instrument by research institutions including universities. The questions were written in simple English to ensure clarity and un-ambiguity and used common terminology, without complicated institutionalized or without engineering discipline terminology. The questionnaire was developed specifically for this study and therefore was never used previously in other studies. It was formulated based on the literature that had been interrogated by the researcher.

The research questionnaire (See Appendix B.4) comprised of five sections. Each section had an average of six closed questions. There were 34 multiple-choice structured questions designed to be answered by clicking (ticking) the most appropriate selection. The questionnaire did not include any biographical data, as it was not deemed necessary by the researcher and individuals that participated in the study because all of the participants were engineers. Furthermore, all the participants registered by Engineering Council of South Africa (ECSA) and exposed to the same engineering environment. Each question in the questionnaire related to each of the five research objectives presented in Chapter 1. The questionnaire was completed electronically hence the participants had to click on the appropriate box to tick the chosen response.

In the qualitative part of the study, the questions were open-ended but having a similar scope as those posed in the quantitative part of the study, while in the quantitative part of the study the question were closed-ended question. For example, in the quantitative part of the study there is a section where the respondents were required to indicate the working relationship between the stakeholders and provides

possible answers to which the respondents had to indicate whether they agreed, strongly agreed, disagreed, or strongly disagreed.

In the qualitative part of the study the same questions were posed to the participants, but participants were asked to provide a broad view on the same possible answers provided in the quantitative part of the study. The participants had to provide an insight based on being the subject matter experts. Both the quantitative respondents and qualitative participants responded indicating their articulations pertaining drivers, causalities and influences and these answers were analyzed using systems thinking.

4.6.1.2 Administration of the research instrument

In the quantitative part of the study the respondents were electronically requested to participate in the study and the link was also electronically distributed. Each request had what is referred to as the Uniform Resource Locator **(**URL) address and clear protocol. For quantitative part, the respondent had to click on the button indicating that he/she is consenting on participating to the voluntary study without monitory gains (the Letter of Informed Consent, appearing in Appendix B.1). All the questionnaires were self-administered.

In the qualitative part of the study, the Letter of Informed Consent was sent to participants (interviewees). The participants gave consent by signing and returning the consent letter before the researcher either personally or telephonically interviewed them. These Letters of Informed Consent were filed as part of the study. Both types of interviews were voice recorded and then transcribed by the researcher.

4.6.1.3 Pretesting of the research instruments

A pilot study was conducted to pre-test the research instruments. The purpose of the pilot study was to determine whether or not the research instruments were not too long and could be finished within 20 to 25 minutes. Furthermore, it was to determine whether or not all the questions asked were clear enough and not ambiguous. Thirdly, it was to solicit any suggestions that could improve the research instruments:

- In the quantitative part of the study the research instrument (questionnaire) was piloted using 5 engineers who have an idea of capital power-infrastructure investments. These engineers only participated in the pilot study but did not participate in the actual study. Two of them were involved in project cost estimation, one involved in strategic investment committees, and two involved in engaging stakeholders.

The reliability of data was tested by scheduling each engineer to answer all questions. The researcher then verified data after each participant has completed the pilot questionnaire, in terms of number of people answered each question and percentage completion (20% for each engineer). The researcher then requested the second participant to answer the questionnaire and verify the accuracy until all five participants completed answering the pilot questionnaire. The researcher further requested feedback regarding clarity and ambiguity of the questionnaire to improve clarity and ensure that questionnaire was unambiguous.

- In the qualitative part of the study two participants participated in the pilot study. All the shortcomings of the interview schedule were addressed before the final questionnaire was sent and actual commencement of actual data collection process. The feedback regarding how the questions could re-worded was suggested and considered.

4.7 DATA ANALYSIS AND PRESENTATION

The quantitative data was collected using the international recognized survey software called Survey Monkey software. It is recognized and professionally accepted by global academic institutions and organizations conducting surveys. The data was presented in the form of the frequency tables and linear regression analysis with conducted using Cronbach's Alpha reliability tests. Quantitative data and regression are presented in Chapter 5.

In the qualitative part of the study the participants' answers were arranged into themes. The responses received from the participants were summarized into themes. The context was presented highly cognizant of popular and dynamic views, the way participants felt about each of the questions asked. The presentation of qualitative data is not presenting the answers of each and every participant to each and every question.

4.8 VALIDITY AND RELIABILITY OF THE STUDY

Validity, according to Brynard et al. (2014), relates to the truthfulness, authenticity, accuracy, and credibility of the data that has been collected. There are many ways to verify whether the data obtained is truthful, accurate, and credible. For example, subject expects could be used to look at the accuracy and credibility of data. Furthermore, peer examination of the data can be used to confirm the accuracy of data. In elections independent observers are used to verify the credibility of information collected in the polling stations. Data is referred to as valid if it is truthful, accurate or credible. For example, if the time of the day is 11pm and the watch indicates that it is 12 pm, then one can conclude that the time

(information) provided by the watch is invalid. In other words, the measuring instrument (the watch) provided invalid information. It is important to note that the researcher is always interested in valid information. In research projects different forms of data collection are used to increase the chances of obtaining accurate data. This method of using different data collection methods is called triangulation. The concept is often used in conjunction with the concept of reliability.

- **Reliability:** Creswell (2014), describe this as ability of the research instrument to provide the same result(s) under the same circumstances. For example, if a watch reads 5pm at the same time every day when the actual time is 5 pm it can be viewed as being reliable. But, even if it were to provide a wrong time, say 4 pm, every day when in fact it is 5 pm it can be viewed as reliable. Its reliability is not based on correctness of the reading, it is based on the fact that it consistently provides the same result (reading) under the same circumstances.

4.9 LOCATION OF THE STUDY

The location of the study for both qualitative and quantitative parts of the research was predominantly in Eskom's KwaZulu-Natal and Johannesburg offices. Only two of the participants participated in the study from Eskom's Cape Town offices.

4.10. ETHICAL CONSIDERATIONS

The University of KwaZulu-Natal has its own Ethics policy. The researcher ensured that all the ethical considerations as stipulated in the University of KwaZulu-Natal's ethics policy were adhered to. The documentations for ethical clearance are attached in Appendices for review. These documents include the following:

- Ethical clearance was granted by the University of KwaZulu-Natal's Ethics Committee and the ethical clearance document is attached to that extent.
- The participants were informed of the aim and objectives of the study.
- The participants were informed of their rights through the letter of informed consent and their consent to participate was obtained through letters of consent.
- The participants were informed of the fact that participation is voluntary, and confidentiality and anonymity would be maintained.
- The participants were informed that they could withdraw at any time if they so wished, without any negative consequence on their part.

4.11 CONCLUSION

The chapter provided an insight on how this study was designed giving indication of which research methodology was used. The chapter indicated that a combination of both quantitative and qualitative methodologies was used. The chapter then indicated that in the case of the quantitative methodology the questionnaire was used as the research instrument whereas in the case of the qualitative methodology the interview was used as the research instrument. The chapter then indicated how the two research instruments were constructed and piloted. The chapter also indicated that the necessary ethical considerations were observed, and that necessary permission to conduct the study was sought and granted both by the University of KwaZulu-Natal and the company within which the study was conducted. The next chapter, chapter 5, provides a presentation and analysis of the data that was collected from both quantitative and qualitative data.

CHAPTER 5

PRESENTATION OF QUANTITATIVE AND QUALITATIVE DATA

5.1 INTRODUCTION

This chapter presents the data that was collected in this research project. As indicated in the research methodology chapter of this report, two sets of data were collected namely quantitative and qualitative data. The chapter first provides the quantitative data followed by the qualitative data. Quantitative data is first presented in a form of a frequency tables and then a brief interpretation of the table is provided.

In the analysis of the qualitative data, the study looked at the responses to each question and then summarized how the majority and the minority of the respondents responded to each question. Where necessary further clarity is provided. For simplicity sake capital power-infrastructure investment project(s) will, at times, be referred to as the project(s). It must be noted that this chapter merely presents the data that was collected the implications of such results are discussed in detail in chapter 6.

5.2 PRESENTATION OF QUANTITATIVE DATA

As indicated in the research methodology chapter the quantitative data was collected using a questionnaire. The questionnaire comprised of 34 questions as a result this section has 34 frequency tables. The possibility of presenting all questions in one table first and present them individually was considered. The data became scholarly unacceptable and cumbersome for data presentation.

Table 5.1: Scope is not adequately defined during concept phase that leads to variations during execution phase

Answer Choices	Responses	
Strongly agree	53.01%	44
Agree	32.53%	27
Neutral	6.02%	5
Disagree	3.61%	3
Strongly disagree	4.82%	4
	Answered	**83**
	Skipped	**7**

The respondents were asked to indicate whether they agreed or disagreed that there was inadequate description of the scope during the concept stage of the capital power-infrastructure investment which then leads to variations during the execution phase of the project. In Table 5.1, it is indicated that 83 (92.2%) out of a total of 90 respondents answered the question. Only 44 (53.01%) of the respondents

have a strong view that the scope is not adequately described during the concept phase which then leads to variations during the execution phase. Table 5.1 further indicates that only a few respondents (3.61% + 4.82%) disagreed and strongly disagreed respectively that the scope is not adequately described, which then leads to variations during the execution phase. Only five (6.02%) respondents could not tell whether the scope was adequately described during the initial phase of the project.

Table 5.2: The costing of work is not adequately done

Answer Choices	Responses	
Strongly agree	18.99%	15
Agree	53.16%	42
Neutral	10.13%	8
Disagree	13.92%	11
Strongly disagree	3.80%	3
	Answered	**79**
	Skipped	**11**

The respondents were asked to indicate whether or not the cost basis of the project does not fulfil the entire capital-infrastructure investment requirements. Table 5.2 indicates that 79 (87.78%) out of a total of 90 respondents answered the question and 11 did not. Furthermore, the table indicates that almost 19% strongly agree and 53.16% agree that cost basis does not fulfil the entire investment requirements. Approximately ten percent (10%) of the respondents indicated neutrality on the mater but almost 14% of the respondents disagreed while nearly four percent (4%) strongly disagree. In the precise analysis, there was the total of 72.15% of the respondents that believe that the cost basis on capital power-infrastructure investments leads to variations towards completion.

Table 5.3: Inadequate construction resource requirements, lead to repetitive power interruption and revenue losses

Answer Choices	Responses	
Strongly agree	32.50%	26
Agree	36.25%	29
Neutral	13.75%	11
Disagree	15.00%	12
Strongly disagree	2.50%	2
	Answered	**80**
	Skipped	**10**

The respondents were asked to indicate whether resource requirements for asset construction are not stipulated properly, thus resulting in repetitive power outages and lose of incentive when negotiating with regulator for tariff increase**.** Table 5.3 indicates that 80 (88.89 %) out of a total of 90 respondents

answered the question. Out of 80 respondents that answered the question, 32.50% strongly agreed those resources' requirements are not adequately stipulated, which results in high frequency of power outages during construction. Only 13.75% of the respondents were neutral on the matter while 15% disagreed and 2.50% strongly disagreed respectively.

Table 5.4: Stakeholders disagreements and power exercise is the major cause for leading to cost of completion uncertainty

Answer Choices	Responses	
Strongly agree	32.50%	26
Agree	38.75%	31
Neutral	11.25%	9
Disagree	15.00%	12
Strongly disagree	2.50%	2
	Answered	**80**
	Skipped	**10**

The respondents were asked to indicate whether or not sstakeholders' disagreements and power exercise is the major cause leading to cost of completion uncertainty. Table 5.4 indicates that out of the total of 90 respondents 80 answered the questions and 10 did not. The table further indicates that 32.50% of the respondents strongly agreed, 38.75% agreed that stakeholders' disagreements and power exercise is the major cause leading to cost of completion uncertainty. In other words, a total of 71.25% stakeholders' disagreements and power exercise is the major cause leading to cost of completion uncertainty. The table indicates that 11.25% were neutral on this question while 15% disagreed and 2.5% strongly disagreed.

Table 5.5: Contracts used during procurement get manipulated by contractors to make more money without delivering asset.

Answer Choices	Responses	
Strongly agree	48.10%	38
Agree	27.85%	22
Neutral	8.86%	7
Disagree	13.92%	11
Strongly disagree	1.27%	1
	Answered	**79**
	Skipped	**11**

The respondents were asked to indicate whether contractors to make more money without delivering the procured asset manipulate contracts used during procurement. Table 5.5 indicates that 79 out of 90 respondents answered the question while 11 did not. The table further indicates that 48.1% of the

respondents strongly agreed and 27.85% agreed that the contractors manipulate the contracts in order to make more money. Only 8.86% of the respondents were neutral on this question while 13.92% indicated that they disagreed and 1.27% strongly disagreed respectively.

Table 5.6: Diplomatic relations with neighbouring countries compromises revenue income and affect investment

Answer Choices	Responses	
Strongly agree	13.95%	12
Agree	43.02%	37
Neutral	32.56%	28
Disagree	8.14%	7
Strongly disagree	2.33%	2
	Answered	**86**
	Skipped	**4**

The respondents were asked to indicate whether or not diplomatic relations with neighboring countries are among challenges that compromise power-utilities income deficit thus affect power-infrastructure investment. Table 5.6 indicates that out of a total of 90 respondents 86 answered the question and four did not. The table further indicates that 12 (13.95%) of the respondents strongly agreed and 37 (43.02%) agreed that diplomatic relationships are among challenges that compromise revenue income for power utilities. This meant that a total of 49 (56.97%) of the respondents agreed with the statement. Almost 33% of the respondents were neutral on this question while seven (8.14%) and two (2.33%) disagree and strongly disagreed respectively.

Table 5.7: Disconnecting non-paying consumers contributes to poor revenue income due to municipalities' political alignment to ruling party

Answer Choices	Responses	
Strongly agree	67.05%	59
Agree	22.73%	20
Neutral	7.95%	7
Disagree	2.27%	2
Strongly disagree	1.14%	1
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether political alignment of municipalities with the ruling party contributes to power utilities' poor revenue. Table 5.7 indicate that out of 90 respondents 88 answered the question while two did not. The table further indicates that 59 (67.05%) strongly agreed and 20 (22.73%) agreed that municipal political alignment is among causes contributing to revenue income deficit, as cutting defaulting consumers could compromise votes to the ruling party.

Furthermore, the table indicates that eight (7.95%) respondents were neutral on this question while two (2.27%) disagreed and 1.14% strongly disagreed respectively.

Table 5.8: Inability to cut off power with neighbouring or local municipality led to Power Purchasing Agreements (PPA) to lose its value.

Answer Choices	Responses	
Strongly agree	31.82%	28
Agree	30.68%	27
Neutral	26.14%	23
Disagree	9.09%	8
Strongly disagree	2.27%	2
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether cross-border power purchasing agreements (PPA) between South Africa and neighboring states have lost its value, as Eskom has never cut off power supply to any country or any local municipality. Table 5 indicates that out of 90 respondents 88 answered the question while two did not. The table further indicates that 28 (31.82%) and 27 (30.68%) strongly agreed and agreed respectively agreed that cross-border power purchasing agreements between South Africa and neighboring states have lost its value. A rather huge number of respondents 23 (26.14%) were neutral on this question which was a bit concerning. The table indicates that eight (9.09%) disagreed with the statement and two (2.27%) strongly disagreed. Two respondents did not answer the question.

Table 5.9: The bilateral trading agreement is not explicit about what are the binding law enforcement avenues to recover payment from defaulting countries

Answer Choices	Responses	
Strongly agree	22.73%	20
Agree	35.23%	31
Neutral	36.36%	32
Disagree	4.55%	4
Strongly disagree	1.14%	1
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether the bilateral trading agreements are not explicit about what are the binding law enforcement avenues to recover payment from defaulting countries. Table 5.9 indicates that 20 (22.73%) of the respondents strongly agreed and 31 (35.23%) agreed respectively that the bilateral agreements are not explicit about the binding law enforcement avenues to recover payment from defaulting countries. The table further indicates that 32 (36.36%) were neutral on this question

while a small number of respondents, four **(**4.55%) disagreed and only 1% strongly disagreed with the statement.

Table 5.10: Lack of in-depth understanding of foreign tax laws are among reasons power utilities are losing revenue income

Answer Choices	Responses	
Strongly agree	17.24%	15
Agree	41.38%	36
Neutral	24.14%	21
Disagree	12.64%	11
Strongly disagree	4.60%	4
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the lack of in-depth understanding of foreign tax laws when providing or receiving services in foreign countries, are among reasons power utilities are losing revenue income. Table 5.10 indicates that out of 90 respondents 87 answered the question while three did not. Table 5.10 further indicates that 15 (17.24%) of the respondents strongly agreed and agreed respectively. The table further indicates that 11 (12.64%) of the respondents were neutral while 11 (12.64%) of them disagreed and four (4.60%) strongly disagreed respectively.

Table 5.11: Townships such as Soweto owing billions of rand should be switched off, paying customers should be temporarily supplied with batteries

Answer Choices	Responses	
Strongly agree	43.68%	38
Agree	31.03%	27
Neutral	6.90%	6
Disagree	13.79%	12
Strongly disagree	5.75%	5
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the townships that are owing utilities billions of rand, such as Soweto, should be switched off to enforce payment and that customers that are paying should be temporarily supplied with alternative supply such as batteries. Table 5.11 indicated that out of 90 respondents 87 answered the question while did not. Table 5.11 further indicates that 38 (43.68%) of the respondents strongly agreed and 27 (31.03%) agreed respectively. The table further indicates that six (66.90%) of the respondents were neutral while 12 (5.75%) of them disagreed and five (5.75%) strongly disagreed respectively.

Table 5.12: Bypassed Large Power Users (LPUs) and Small Power Users (SPUs) should have their direct infrastructure removed and re-apply when willing to pay timeously

Answer Choices	Responses	
Strongly agree	42.05%	37
Agree	42.05%	37
Neutral	4.55%	4
Disagree	7.95%	7
Strongly disagree	3.41%	3
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether bypassed power users should have their direct infrastructure removed and then re-apply for reconnection when they are willing to pay timeously. Table 5.12 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.12 further indicates that 37 (42.05%) of the respondents strongly agreed and 37 (42.05%) agreed respectively. The table further indicates that four (4.55%) of the respondents were neutral while seven (7.95%) of them disagreed and three (3.41%) strongly disagreed respectively.

Table 5.13: If politicians can always emphasize the need for electricity payment, utilities revenue income can improve

Answer Choices	Responses	
Strongly agree	57.47%	50
Agree	31.03%	27
Neutral	5.75%	5
Disagree	3.45%	3
Strongly disagree	2.30%	2
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the politicians can emphasize the need for electricity payment, thus improving revenue income. Table 5.13 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.13 further indicates that 50 (57.47%) of the respondents strongly agreed and 27 (31.03%) agreed respectively. The table further indicates that five (5.75%) of the respondents were neutral while three (3.45%) of them disagreed and 2 (2.30%) strongly disagreed respectively.

Table 5.14: Private, Public Partnership (PPP) in power-infrastructure investment will ease government's constrained budget of infrastructure development and maintenance

Answer Choices	Responses	
Strongly agree	22.73%	20
Agree	50.00%	44
Neutral	7.95%	7
Disagree	15.91%	14
Strongly disagree	3.41%	3
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether private, public partnership (PPP) in power-infrastructure investment can ease government's burden in infrastructure development and maintenance. Table 5.14 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.14 further indicates that 20 (22.73%) of the respondents strongly agreed and agreed respectively. The table further indicates that seven (7.95%) of the respondents were neutral on this question while 14 (15.91%) of them disagreed and three (3.41%) strongly disagreed respectively.

Table 5.15: Government Department that are providing essential services should be funded through fixed rate not linked through credit rating

Answer Choices	Responses	
Strongly agree	20.69%	18
Agree	48.28%	42
Neutral	20.69%	18
Disagree	5.75%	5
Strongly disagree	4.60%	4
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether ggovernment departments that are providing essential services should be funded through fixed rate not linked through credit rating. Table 5.15 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.15 further indicates that 18 (20.69%) of the respondents strongly agreed and 42 (48.28%) agreed respectively. The table further indicates that 18 (20.69%) of the respondents were neutral while five (5.75%) of them disagreed and four (4.60%) strongly disagreed respectively.

Table 5.16: Some Large Power Users (LPUs) such as mines, commercial, industries are among major contributors to power utility's poor revenue income as they bypass meters.

Answer Choices	Responses	
Strongly agree	22.99%	20
Agree	25.29%	22
Neutral	21.84%	19
Disagree	24.14%	21
Strongly disagree	6.90%	6
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether some of the large power users (LPUs) such as mines, commercial, industries are among major contributors to the power utility's poor revenue income as they bypass meters. Table 5.16 indicated that out of 90 respondents, 87 answered the question while three did not. Table 5.16 further indicates that 20 (22.99%) of the respondents strongly agreed and 22 (25.29%) agreed respectively. The table further indicates that 19 (21.84%) of the respondents were neutral while six (6.90%) of them disagreed and 21 (24.14%) strongly disagreed respectively.

Table 5.17: The fine amount paid by non-paying consumers or meter tempers, is small compared to what they would have paid monthly

Answer Choices	Responses	
Strongly agree	31.82%	28
Agree	50.00%	44
Neutral	10.23%	9
Disagree	5.68%	5
Strongly disagree	2.27%	2
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether or not the fine amount that is paid after numerous years of non-payment is extremely small compared to what the consuming non-payer or meter temper would have paid on their monthly basis. Table 5.17 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.17 further indicates that 28 (31.82%) of the respondents strongly agreed and 44 (50.00%) agreed respectively. The table further indicates that nine (10.23%) of the respondents were neutral while five (5.68%) of them disagreed and two (2.27%) strongly disagreed respectively.

Table 5.18: The collusion of coal supplying mines impacts on tariff increases, consumers are not affording leading to revenue shortfall

Answer Choices	Responses	
Strongly agree	46.59%	41
Agree	36.36%	32
Neutral	10.23%	9
Disagree	4.55%	4
Strongly disagree	2.27%	2
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether mines that supply coal to the power utility collude to increase coal cost, thus resulting in tariff increases, which in turn cause the consumers to fail to pay for electricity. Such non-payments result in utilities' revenue shortfall**.** Table 5.18 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.18 further indicates that 41 (46.59%) of the respondents strongly agreed and 32 (36.36%) agreed respectively. The table further indicates that nine (10.23%) of the respondents were neutral while four (4.55%) of them disagreed and two (2.27%) strongly disagreed respectively.

Table 5.19: At conceptual stage, stakeholders should enlist their expectations to avoid additional costs during project construction

Answer Choices	Responses	
Strongly agree	32.50%	26
Agree	38.75%	31
Neutral	11.25%	9
Disagree	15.00%	12
Strongly disagree	2.50%	2
	Answered	**80**
	Skipped	**10**

The respondents were asked to indicate whether the additional costs required to fulfil stakeholders' expectations during project construction, could be used in other projects. Table 5.19 indicated that out of 90 respondents 80 answered the question while ten did not. Table 5.19 further indicates that 26 (32.50%) of the respondents strongly agreed and 31 (38.75%) agreed respectively. The table further indicates that nine (11.25%) of the respondents were neutral while 12 (15.00%) of them disagreed and two (2.50%) strongly disagreed respectively.

Table 5.20: Deploying power utilities' resources to critical external stakeholders will quicken issuing of permits

Answer Choices	Responses	
Strongly agree	35.23%	31
Agree	37.50%	33
Neutral	12.50%	11
Disagree	9.09%	8
Strongly disagree	6.82%	6
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether the performance of critical external stakeholders such as the Department of Environmental Affairs can be improved by deploying power utilities' resources to be housed within that department to speed up constraining permits. Table 5.20 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.20 further indicates that 31 (35.23%) of the respondents strongly agreed and 33 (37.50%) agreed respectively. The table further indicates that 11(12.50%) of the respondents were neutral while eight (9.09%) of them disagreed and six (6.82) strongly disagreed respectively.

Table 5.21: The project manager should compact stakeholders and do performance assessment (PA) during after the project is completed.

Answer Choices	Responses	
Strongly agree	60.92%	53
Agree	26.44%	23
Neutral	4.60%	4
Disagree	5.75%	5
Strongly disagree	2.30%	2
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the project manager should compact stakeholders and do performance assessment during and after the project is completed. Table 5.21 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.21 further indicates that 53(60.92%) of the respondents strongly agreed and 23 (26.44%) agreed respectively. The table further indicates that four (4.60%) of the respondents were neutral while five (5.75%) of them disagreed and two (2.30%) strongly disagreed respectively.

Table 5.22: The trade union bargaining issues are the major causes affecting project cost and schedule leading to increased expenditure due to undertaking insurance.

Answer Choices	Responses	
Strongly agree	13.79%	12
Agree	18.39%	16
Neutral	19.54%	17
Disagree	29.89%	26
Strongly disagree	18.39%	16
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the trade union bargaining issues are the major causes affecting project cost and schedule leading to increased expenditure. Table 5.22 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.22 further indicates that 12 (13.79%) of the respondents strongly agreed and 16 (18.39%) agreed respectively. The table further indicates that 17 (19.54%) of the respondents were neutral while 26 (29.89%) of them disagreed and 16 (18.39%) strongly disagreed respectively.

Table 5.23: Investment opportunities are also affected by stakeholders' politics on Expanded Public Works Program (EPWP) leading to project delays and cost overrun

Answer Choices	Responses	
Strongly agree	22.09%	19
Agree	37.21%	32
Neutral	22.09%	19
Disagree	12.79%	11
Strongly disagree	6.98%	6
	Answered	**86**
	Skipped	**4**

The respondents were asked to indicate whether the stakeholders' politics due to Expanded Public Works Program (EPWP) leads to project delays and cost overrun. Table 5.23 indicated that out of 90 respondents 86 answered the question while four did not. Table 5.23 further indicates that 19 (22.09%) of the respondents strongly agreed and 32 (37.21%) agreed respectively. The table further indicates that 19 (22.09%) of the respondents were neutral while 11 (12.79%) of them disagreed and six (6.98%) strongly disagreed respectively.

Table 5.24: The ROI analysis done during the feasibility is not realized in most of the capital power-infrastructure projects

Answer Choices	Responses	
Strongly agree	32.95%	29
Agree	39.77%	35
Neutral	18.18%	16
Disagree	6.82%	6
Strongly disagree	2.27%	2
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether return on investment analysis done during the feasibility is realized in most of the capital power-infrastructure projects. Table 5.24 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.24 further indicates that 29 (32.95%) of the respondents strongly agreed and 35 (39.77%) agreed respectively. The table further indicates that 16 (18.18%) of the respondents were neutral while six (6.82%) of them disagreed and two (2.27%) strongly disagreed respectively.

Table 5.25: The Internal Rate of Return (IRR) analysis done during the feasibility is not realized in most of the capital power-infrastructure projects

Answer Choices	Responses	
Strongly agree	27.59%	24
Agree	44.83%	39
Neutral	21.84%	19
Disagree	5.75%	5
Strongly disagree	0.00%	0
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether or not the internal rate of returns (IRR) analysis done during the feasibility stage of the project are realized in most of the capital power-infrastructure projects**.** Table 5.25 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.25 further indicates that 24 (27.59%) of the respondents strongly agreed and 39 (44.83%) agreed respectively. The table further indicates that 19 (21.84%) of the respondents were neutral while five (5.75%) of them disagreed and none strongly disagreed.

Table 5.26: The initial forecasted Net Present Value (NPV), in most capital power-infrastructure investment is not realized

Answer Choices	Responses	
Strongly agree	26.14%	23
Agree	45.45%	40
Neutral	18.18%	16
Disagree	10.23%	9
Strongly disagree	1.14%	1
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether the initial forecasted Net Present Value (NPV), in most capital power-infrastructure investment is not realized. Table 5.26 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.26 further indicates that 23 (26.14%) of the respondents strongly agreed and 40 (45.45%) agreed respectively. The table further indicates that 16 (18.18%) of the respondents were neutral while nine (10.23%) of them disagreed and one (1.14%) strongly disagreed respectively.

Table 5.27: The viability of electrification and/or township infrastructure investments should include dedicated law enforcement resources

	Responses	
Strongly agree	28.74%	25
Agree	43.68%	38
Neutral	16.09%	14
Disagree	9.20%	8
Strongly disagree	2.30%	2
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the electrification of township infrastructure should include dedicated law enforcement resources. Table 5.27 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.27 further indicates that 25 (28.74%) of the respondents strongly agreed and 38 (43.68%) agreed respectively. The table further indicates that of the respondents were neutral while eight (9.20%) of them disagreed and two (2.3%) strongly disagreed respectively.

Table 5.28: Ability to link credit rating or with internet or cellular phone will help improve timeous payment

Answer Choices	Responses	
Strongly agree	22.73%	20
Agree	39.77%	35
Neutral	15.91%	14
Disagree	20.45%	18
Strongly disagree	4.55%	4
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether power purchase to internet would help improve the revenue income. Table 5.28 indicated that out of 90 respondents answered the question while two did not. Table 5.28 further indicates that 20 (22.73%) of the respondents strongly agreed and 35 (39.77%) agreed respectively. The table further indicates that 14 (15.91%) of the respondents were neutral while 18 (20.45%) of them disagreed and 18 (20.45%) strongly disagreed respectively.

Table 5.29: The new financial evaluation model that will include the percentage risk of non-payment payment, investment recovery, time of investment is required

Answer Choices	Responses	
Strongly agree	26.44%	23
Agree	50.57%	44
Neutral	17.24%	15
Disagree	5.75%	5
Strongly disagree	0.00%	0
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the new financial evaluation model that includes the percentage risk of non-payment payment, investment recovery, and time of investment is required. Table 5.29 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.29 further indicates that 23 (26.44%) of the respondents strongly agreed and 44 (50.57%) agreed respectively. The table further indicates that 15 (17.24%) of the respondents were neutral while five (5.75%).

Table 5.30: Procurement of goods and services from foreign countries is the major cause for the delay leading to Interest During Construction (IDC) to demand cost increases

Answer Choices	Responses	
Strongly agree	27.27%	24
Agree	35.23%	31
Neutral	10.23%	9
Disagree	17.05%	15
Strongly disagree	10.23%	9
	Answered	**88**
	Skipped	**2**

The respondents were asked to indicate whether procurement of goods and services from foreign countries is the major cause for the delay leading to cost increases. Table 5.30 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.30 further indicates that 24 (27.27%) of the respondents strongly agreed and 31 (35.23%) agreed respectively. The table further indicates that nine (10.23%) of the respondents were neutral while 15 (17.05%) of them disagreed and 9 (10.23%) strongly disagreed respectively.

Table 5.31: The South African labor rights to strike delays freight system, increases transportation insurance and increases investment delay costs

Answer Choices	Responses	
Strongly agree	19.54%	17
Agree	45.98%	40
Neutral	18.39%	16
Disagree	10.34%	9
Strongly disagree	5.75%	5
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the South African labour laws increase investment costs. Table 5.10 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.10 further indicates that 17 (19.54%) of the respondents strongly agreed and 40 (45.98%) agreed respectively. The table further indicates that 16 (18.39%) of the respondents were neutral while nine (10.34%) of them disagreed and 5 (5.75%) strongly disagreed respectively.

Table 5.32: The environment of operation such as Supplier Development and Localization (SD &L), Original Equipment Manufacturing (OEM) causes delay of infrastructure development

Answer Choices	Responses	
Strongly agree	20.69%	18
Agree	45.98%	40
Neutral	20.69%	18
Disagree	9.20%	8
Strongly disagree	4.60%	4
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether the environment of operation including regulating laws such as Supplier Development and Localization (SD&L), Original Equipment Manufacturing (OEM), contractual agreements and local community expectations contribute to the delays in power-infrastructure. Table 5.32 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.32 further indicates that 18 (20.69%) of the respondents strongly agreed and 40 (45.98%) agreed respectively. The table further indicates that 18 (20.69%) of the respondents were neutral while eight (9.20%) of them disagreed and four (4.60%) strongly disagreed respectively.

Table 5.33: The contract signed between two parties get manipulated by the seller in order to take advantage of the of the power utility thus increasing the investment cost

Answer Choices	Responses	
Strongly agree	19.54%	17
Agree	36.78%	32
Neutral	20.69%	18
Disagree	18.39%	16
Strongly disagree	4.60%	4
	Answered	**87**
	Skipped	**3**

The respondents were asked to indicate whether or not the contract signed between two parties get manipulated by the seller in order to take advantage of the power utility thus increasing the investment cost. Table 5.33 indicated that out of 90 respondents 87 answered the question while three did not. Table 5.33 further indicates that 17 (19.54%) of the respondents strongly agreed and 32 (36.78%) agreed respectively. The table further indicates that 18 (20.69%) of the respondents were neutral while 16 (18.39%) of them disagreed and four (4.60%) strongly disagreed respectively.

Table 5.34: The foreign companies to supervise during skills transfer local companies do, the IP and lessons learnt to remain in South Africa

Answer Choices	Responses	
Strongly agree	37.50%	33
Agree	38.64%	34
Neutral	11.36%	10
Disagree	9.09%	8
Strongly disagree	3.41%	3
	Answered	**88**

The respondents were asked to indicate whether foreign companies can play supervisory role where their skills are required, the doers should be the local companies and intellectual properties including lessons learnt, procedure of commissioning should remain in South Africa. Table 5.34 indicated that out of 90 respondents 88 answered the question while two did not. Table 5.34 further indicates that 33 (37.50%) of the respondents strongly agreed and 34 (38.64%) agreed respectively. The table further indicates that 10 (11.36%) of the respondents were neutral while eight (9.09%) of them disagreed and 3 (3.41%) strongly disagreed respectively.

5.2.1 Conceptual understanding of regression analysis

It is imperative to conceptualize the background of what regression analysis is. The regression analysis provides a statistical modelling to understand logical interpretation of questions in relations to one another and these are called independent and dependent variables. These variables assist in the determination of the strength of the relationship. Although there are various regression analysis variation techniques available and they all differ according to the fundamental purpose used for, namely linear, multiple linear and nonlinear regression.

In section 3.5.2, the variable relationship between GDP and capital investments demonstrated its dependence to other factors such as sovereign credit rating. These two have unrelated or non-related. The question that remains to be understood is “Capital power infrastructure investment” made in any power utility has the relationship with the economic growth in that power utility? It is believed that capital power infrastructure investment creates opportunities for companies to stimulate economic growth. The dependent variable in this question is “The capital power infrastructure investment” and independent variable will be “Economic growth in the country”.

In plotting this in the regression analysis, there are two axes namely Y axis and X axis. The Y axis will be for dependent variable and “economic growth in the country” will be in the X axis as an independent

variable. This means that the “economic growth in the country” is independent from “capital power infrastructure investment”, arguably so.

In section 3.5, the review in literature cited evidently to deduce that capital power infrastructure investment can be reprioritized for maintenance backlog, already impacted by regulatory framework. The capital power infrastructure investment includes development of power infrastructure for electrification purpose. Operation and maintenance of that electrification infrastructure means contribution to the Total Cost of Asset Ownership (TCAO). It is therefore for that reason capital power infrastructure investment does not have the linear relationship with economic growth of that country.

In the example that has been made, the regression analysis proves logical thinking of the respondent when they were answering questions with understanding or it was just a ticking exercise. This is easily determined through analysis how all 90 respondents have answered consistently between both dependent and independent variables.

5.2.1 Presentation of regression data analysis

The set of survey questions were crafted to answer the main research questions in section 1.6. There were 6 pairs or sets of questions directly related to capital power infrastructure investments. The regression analysis on these questions will provide a clear relationship between dependent and independent variables

There are various regression analysis assumptions made such as linearity, independence, homoscedasticity and normality, to be considered selection of certain regression analysis technique. The selection of the technique to utilize depends on the assumptions related to the data collected and the purpose of the analysis. In this study, the researcher performed the Linear Regression on some questions to predict the value of a variable (dependent variable), based on the value of another valuable (independent variable). Before conducting the linear regression, the researcher had to make sure that the data meet at least the four different above-mentioned assumptions for the linear regression, in order to give valid and reliable results. It must be taken into consideration that with the real-world data, there is a great possibility that collected data may fail to meet one or more of the four assumptions. It is however usually possible to have a solution to overcome certain violations. The researcher conducted different tests to detect if the four assumptions were met or not. The tests included scatter plot test and t-test for linearity, Durbin-Watson test for independence, including fitted value and residual plot for homoscedasticity to detect if heteroscedasticity is present, and Q-Q plots for normality.

Cronbach alpha reliability statistics provides procedural guidance with specific limits as detailed in the following Table 5.35.

Table 5.35: CRONBACH ALPHA RELIABILITY STATISTICS

Cronbach's Alpha	N of cases	N of Items
.763	90	12

The Frequency Table 5.35 is the presentation of the Cronbach's Alpha reliability test which was performed to measure consistency of data presented or lack thereof. According to authors like Sekaran and Bougie (2016), and Creswell and Creswell (2017), if Cronbach's coefficient is above 0.6, data can be considered as having internal consistency. The above table shows that 90 participants were included in measuring consistency and indicates that Cronbach's Alpha is .763 of 12 items. It can therefore be concluded that there is a strong internal consistency of responses since the figure .763 is above .6, as per indication of the authors mentioned above.

In the following Table 5.36 is an example of Question 1 asking about the adequate definition of the scope, Question 2 asking about cost increases and Question 3 asking about the schedule variance. In infrastructure development, these are the fundamental knowledge requirements. They question what is required to be done, how much will it cost and when will it be done. It is expected for the respondent to exercise due diligence in answering these questions, as they have relationship.

Table 5.36: Variables for regression analysis

Research Question	Independent variable	Dependent variable
What could be the challenges regarding development of power-infrastructure capital investments in South Africa?	Survey Question 1: Scope is not adequately defined during concept phase that leads to variations during execution phase	Survey Question 2: The cost basis does not fulfil entire capital power-infrastructure investment requirement
Research Question 2: What systems thinking could determine as an impact that the procurement of long lead goods and contracting of foreign skills have on projects?	Survey Question 3: Resource requirements for asset construction are not stipulated properly; this results in repetitive power outages and lose incentive when negotiating with regulator for tariff increase	Survey Question 5: Contracts used during procurement get manipulated by contractors to make more money without delivering asset.

Research Question 3: What could be the systemic model formulated to evaluate the long-term power-infrastructure investment in South Africa?	Survey Question 26: The initial forecasted Net Present Value (NPV), in most capital power-infrastructure investment is not realized	Survey Question 29. The new financial evaluation model that will include the percentage risk of non-payment payment, investment recovery, time of investment is required
Research Question 4: What would be the extent of investment opportunities lost due to costs escalations using stakeholder analysis?	Survey Question 19: The additional costs required to fulfil stakeholders' expectations during project construction, could have been used in another project, should stakeholders had enlisted their expectations during conceptual stage	Survey Question 24: The ROI analysis done during the feasibility is not realized in most of the capital power infrastructure projects
Research Question 5: What impact would timeous payment by debtors have in capital power-infrastructure investments in South Africa?	Survey Question 6: Diplomatic relations with neighbouring countries are among challenges that compromises power-utilities revenue's income deficit thus affect power-infrastructure investment	Survey Question: 8: The cross-border Power Purchasing Agreements (PPA) between South Africa and neighbouring countries have lost its value, as Eskom has never cut off power supply to any country or any local municipality
	Survey Question 10: The bilateral trading agreement is not explicit about what are the binding law-enforcement avenues, to recover payment from defaulting countries	Survey Question 9: Lack of in-depth understanding of foreign tax laws when providing or receiving services in foreign countries, are among reasons power utilities are losing revenue income

5.2.2 Interpreting linear regression

The size of the coefficient for each independent variable determines the size of the effect that the variable has on the dependent variable, and the sign on the coefficient (be it positive or negative) gives the direction of the effect. Furthermore, the relationship is statistically significant if the P value for the

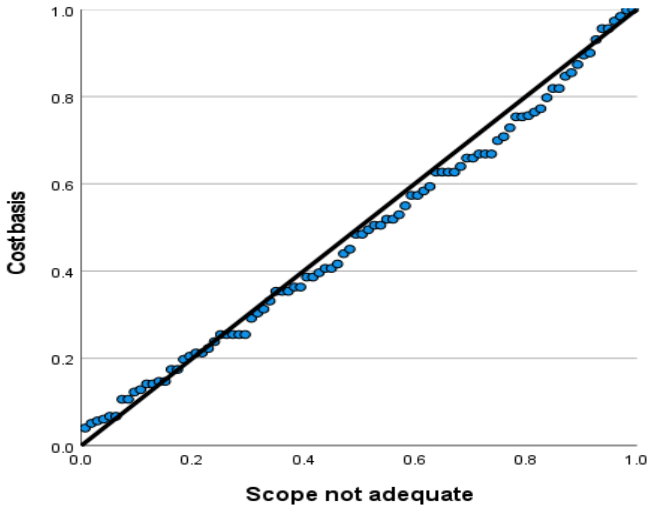
overall F-test is less than your significance level, you can conclude that the R-squared value is significantly different from zero. According to Minitab Blog Editor (2013: np), a low p-value of <0.05 "is likely to be more meaningful to your model because changes in the predictor's value are related to changes in the response variable.", a larger p-value is insignificant since changes in the predictor value do not relate to the changes in responses.

Linear Regression is a model base technique that is an extension of Pearson Correlation. Below are questions on which linear regression was performed in line with the six objectives of the study.

5.2.2.1 Regression analysis results on six pairs of questions

Table 5.37: Regression analysis between scope not adequately defined versus cost variance

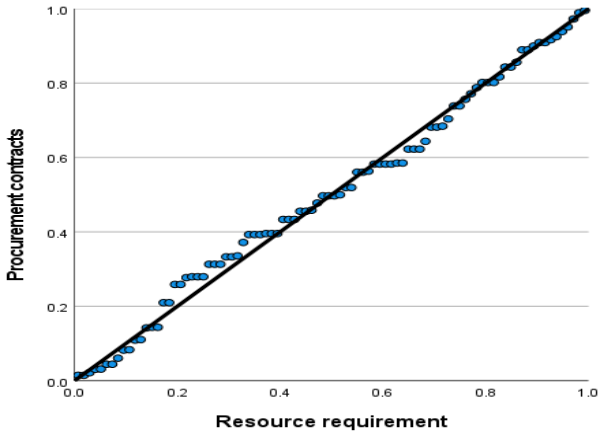
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.653	2.195		4.399	.000
	Scope not adequate	6.230	.732	.672	8.517	.000



The p-value for the independent variable is .000 significant, which is <0.05, thus suggesting that changes in the predictor value are associated with changes in the response variable. The coefficient table further that the inadequate scope which is rated at 6.23 shows an average agreement/disagreement increase of 6.23. The P-P plot on the graph shows that those who agreed that the scope is not adequately defined during concept phase, agreed that the cost basis does not fulfil entire capital power-infrastructure investment requirement; and those that did not agree that the scope is not adequately defined during concept phase also did not agree the cost basis does not fulfil entire capital power-infrastructure investment requirement.

Table 5.38: Poorly stipulated resource requirements versus procurement contract that get manipulated to make more money

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	68.308	1.428		47.842	.000
	Resource requirement	5.348	.416	.808	12.854	.000

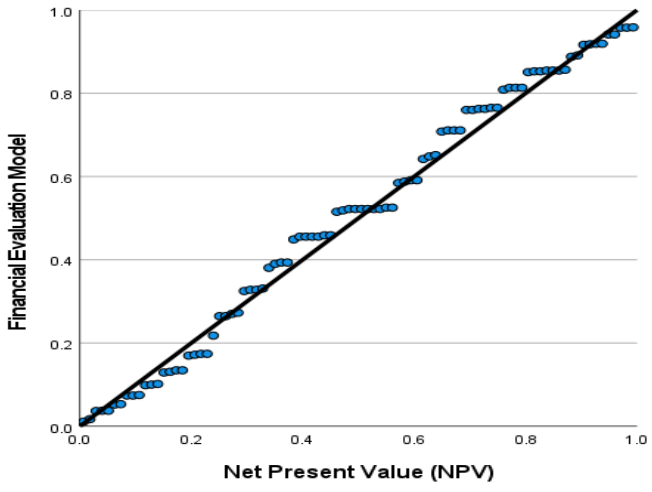


The p-value for the two variable is .000 significant, which is <0.05, thus suggesting that changes in the predictor value are associated with changes in the response variable. The coefficient table further indicates that the coefficient for resource requirement which is rated at 5.35 shows an average

agreement/disagreement increase of 5.35. The P-P plot on the graph shows the same information, indicating that those who agreed that resource requirements for asset construction are not stipulated, agreed that contracts used during procurement get manipulated. While at the same those who disagreed that resource requirements for asset construction are not stipulated, also disagreed that contracts used during procurement get manipulated

Table 5.39: NPV not realized versus new required financial evaluation model to include percentage risk of non-payment payment, investment recovery, time of investment is required

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.569	1.521		4.976	.000
	NPV	7.050	.632	.765	11.152	.000



The p-value for the two variable is .000 significant, which is <0.05, thus suggesting that changes in the predictor value are associated with changes in the response variable. The P-P plot on the graph shows the same information, indicating that those who agreed that the Net Present Value (NPV), in most capital power-infrastructure investment is not realized agreed that the new financial evaluation model

that will include the percentage risk of non-payment payment, investment recovery, time of investment is required. While at the same those who disagreed that the Net Present Value (NPV), in most capital power-infrastructure investment is not realized also disagreed that the new financial evaluation model that will include the percentage risk of non-payment payment, investment recovery, time of investment is required.

Table 5.40 The additional costs required to fulfil stakeholders' expectations during project construction versus analysis of ROI not being realized

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.374	1.905		2.296	.024
	Additional costs	6.264	.563	.764	11.125	.000

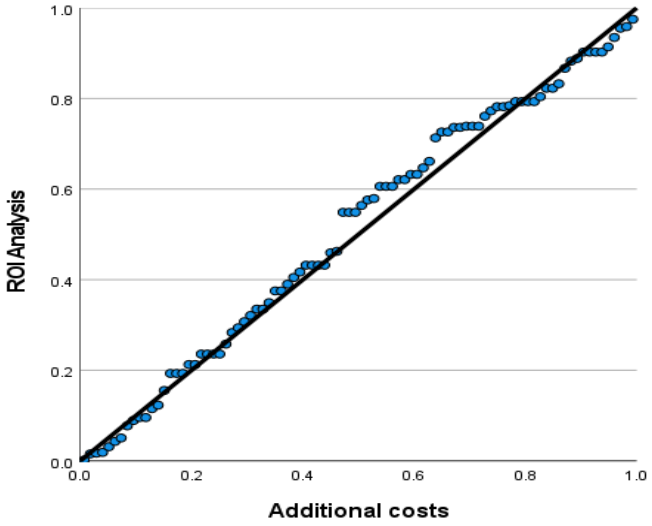
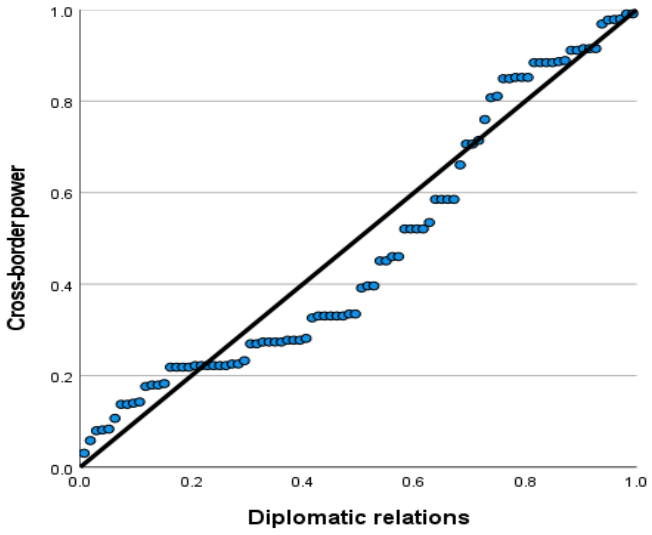


Table 5.41: South Africa's diplomatic relations versus lost value of Power Purchasing Agreements (PPA)

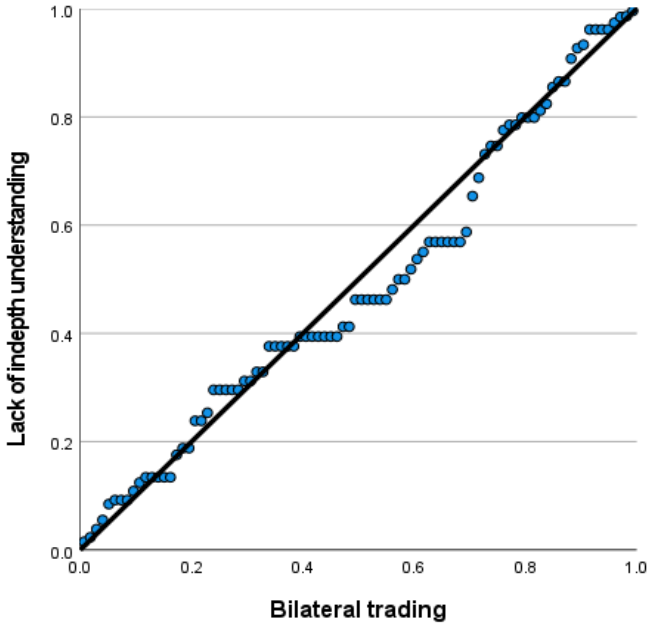
Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.827	1.705		5.764	.000
	Diplomatic relations	1.928	.623	.313	3.095	.003



The p-value for the independent variable is .003 significant, which is <0.05, thus suggesting that changes in the predictor value are associated with changes in the response variable. The P-P plot on the graph shows the same information, indicating most of those who agreed that diplomatic relations compromise power utility revenues agreed that the cross-border Power Purchasing Agreements (PPA) between South Africa and neighbouring countries have lost its value. While at the same those who disagreed that diplomatic relations compromise power utility revenues disagreed that the cross-border Power Purchasing Agreements (PPA) between South Africa and neighbouring countries have lost its value

Table 5.42: Bilateral trading agreement, not explicit on binding laws enforcement versus not understanding of foreign tax laws on international trading

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.362	1.230		1.108	.271
	Bilateral trading	5.788	.488	.784	11.853	.000



The p-value for the independent variable is .000 significant, which is <0.05, thus suggesting that changes in the predictor value are associated with changes in the response variable. The P-P plot on the graph shows the same information, indicating most of those who agreed that the bilateral trading agreement is not explicit about the binding law enforcement avenues agreed that there is lack of in-depth understanding of foreign tax laws when providing or receiving services in foreign countries. While at the same those who disagreed that the bilateral trading agreement is not explicit about the binding law enforcement avenues disagreed there is lack of in-depth understanding of foreign tax laws when providing or receiving services in foreign countries.

5.3 PRESENTATION AND ANALYSIS OF QUALITATIVE DATA

The main purpose for this section is to present the qualitative research, the number of respondents that responded together with high level of their credentials and analysed results. It is the aim of this section to present the procedure followed when conducting the study and the content from individual responses and combined analytical results.

The qualitative research interview was conducted according to the stipulated UKZN approved ethical process, following the Creswell (2018, p.166) guide. The appointments were set mostly with Eskom executives that are involved in the capital power-infrastructure investment process. The consent letters were sent to the participant, signed according to ethical requirements. When starting interview, the researcher reminded the participant that the interview was audio recorded, he has the right not to answer a specific question or totally withdraw from the interview. The respondents knew that the results should be archived by University of KwaZulu Natal for five years.

It was further explained that the interview was completely voluntary and without monetary gains. The audio-recordings conducted through the cellular phone were downloaded to the laptop and saved together with consent forms.

There were five open-ended questions sent to each participant as the interview guide before the interview. Each participant had to respond based on his or her experience.

5.4 THE QUALITATIVE RESEARCH INTERVIEWS QUESTIONS

As indicated in the research methodology chapter, there were seven respondents in the qualitative part of the study. Furthermore, the questions that the respondents were expected to answer, were based on five broad themes. These broad themes originated from structuring the quantitative research questionnaire.

The first question expected the respondents to broadly indicate what they, as experienced executives of the power utility, believed to be the major reasons that led to uncertainty of cost-to-completion of capital power-infrastructure investment

All seven respondents responded to this broad question. The respondents responded based on their own experience. The answers from the respondents resonated or at times complemented each other. Although this question was asked to all respondents, during the interview process follow up questions or supplimenting questions were posed.

Summarily, respondents responded by stating six amongst other reasons that leads to cost to completion uncertainty. These reasons are all mentioned in this study as the following:

The first being the subject matter expert employees used in the 1980s for cost estimation were no longer available. The employees that were still available within Eskom, exposed to power stations designs, were young and inexperienced in the 1980s when Eskom stopped designing and developing power stations. This means that skills related to power station design, construction and project management has delapilated. Further to that, there was insufficient time to train young engineers as government of South Africa disinvested in coal power stations skills development. This is because government's plans were to develop renewable energy as part of the energy mix.

They continued stating that government realized that power shortage was becoming the state of emergency. The participant elaborated using the narrative similar to the approach of building the house without proper planning. In other words it was to start building without houseplan, without knowledge of the number of bedrooms required, whether the house will be double-story or not, without knowledge whether will have the swimming pool or not. The urgency of building this house, provided inadequate time for the acquisition of suitable architecture and builders. Furthermore it meant inadequate time of engaging various material suppliers and agree on quantities of material required, cost in order to budget and schedule financing accordingly. Another participant narrated this in a manner that building the house takes nine months but forced to complete the house within five months as it is urgent. It become an acceptable tendency to accept the first architecture, the first builder who gives you the qoutation and you end up paying costly for services that would have been cheaper have you had an oportunity to test the market and compare average cost per square meter.

The respondents indicated that it was the similar case in the building Medupi, Kusile and Ingula power stations. The previous built power stations within South Africa and global trend took seven years to construct the power station to completion but Eskom had to finish construction of these power stations within five years. The respondents stated this as one result of poor planning, and poor cost estimation for capital investment required. *"When realizing that the you have the infrastructure to build and it takes seven years but you want to have this infrastructure built in five years, this means you do not have slack time and it means insufficient planning. You end-up going into implementation before detailed planning. Because of that, you do not have a good sense of cost to completion.. This was the case for Medupi and Kusile. You tend to accept any architecture or any contractor you come across".* This resulted in the acceptance of possible cost escalation but unknowingly to what extent will the cost escalate to.

- **The first follow up question was to ask if there was not any form of ceiling or maximum price to agreed upon with contractors.**

All respondents that were asked this question answered that there was no ceiling or maximum price. Another participant stated that this was due to the fact that the contract was signed in foreign currency and most of the goods were imported from various foreign countries. Therefore the cost variation was also dependent on foreign exchange rate at that time. The same participant further stated that power-infrastructure capital investment projects are usually huge and complex. The contractors and material suppliers had a global footprint, they know what to get from what country including profit margin which was a disadvantage for Eskom at that time and still is until today. Another participant made an example that when foreign goods and services are more than 70%, the cost modification for additional work or certain components makes cost variation in rand value to be high when the contract is in foreign currency, thus impacting severely when converted to rand value.

In reverting back to how all other respondents responded, they all stated that poor planning was among the reasons. They all stated that these power stations were being designed whilst they were being constructed. Reverting back to the example made regarding building the house. It was like starting with excavation for house building without knowing how big is the house required. When constructing the house you may realize later that you have laid bricks and done plastering in the place where windows were supposed to be. The changes to make corrections will have both cost and schedule implications. *"If someone tells you that you will need the house but you have not drawn the house and have not sumitted to deeds office and you do not have the builder, no bill of quantities and average cost per square meter,in that way you havethe better feeling of how to cost the project. In this instance there was no sufficient time for that hence cost escalated"*

- **The second follow up question was to ask if there was no direct policy related to capital power-infrastructure development which could have been applied for decision making.**

All of the respondents stated that there is an existing Process Lifecycle Control Manual (PLCM) but not conjucive for mega-infrastructure projects with long duration. It was developed through lessons learnt from various projects. This was to ensure that there are stage gates for the approval of initiatives by investment committes. In terms of this process, the investment committte has to review the strategic alignment of every initiative and make the decision regarding its approval from start, at the conceptual stages, and it must return for every stage gate approval until completion.

Another participant responded in a contrary manner stating stated that Eskom started collecting information as early as 2004 from international companies. This information was pertaining to baseline costing of how much does it cost per kilowatt hour to build the power station. Using the information that was provided by various international companies, Eskom engaged in the discussion that included that design, costing model and related construction activities. In that discussion, the cost of generating the unit of kwh was ascertained. This is called Levelized Cost of Energy (LCOE).

The participant made an example that the LCOE is like making calculations as to how does it cost to produce a cigarette or box of cigarette. In arriving to that cost, the costs associated with fuel for ploughing the field, water it, how much labourers cost, harvesting cost , package and deliver it to sellers. This will be the deterministic factor how much you should be charging in order to realize returns.

The respondents stated that during those discussions, the LCOE for generating each kwh at that stage for the coal fired power station was around USD $2300/kwh to USD $2400/kwh installed. At the end 2018, the costing of the kilowatt installed had inflated and costing at a range of USD $2900. This is among reasons that has to led to uncertainty of cost to completion. The participant further stated that Eskom would not have started contracting when the LCOE was lower, because at that time, due to the fact that in countries such as India, Poland and Germany procurement was at least four years process to complete. That time was required to complete construction of the power station in South Africa. The respondents further stated that allowing another four years to lapse would have been the economical and political catastrophy in South Africa.

The second contributing reason to uncertainty in cost to completion was timing, as it was the sellers market timeframe and South Africa was desperate. There was a global market demand for these power-infrastructure capital investments, many countries in the world were busy developing mega capital power-infrastructure and competing for the similar resources. It is normal that when suppliers are in demand, the highest bidder gets attention more than the lowest bidder. In such situations, it is normal that the available resources are those that missed other opportunities or the one with more resources. The desperation of South Africa resulted in contracting at a higher cost than worldwide cost. The participant made an example by stating that if the resource was costing USD $100 per day but just because South Africa was desperate the resource ended costing USD $500 per day.

In other words, even if proper planning was conducted in the upfront planning, and everyone is busy developing these similar project worldwide, power utilities will be competing for the same resources. It becomes expensive to secure those resources as suppliers will increase cost and only those that are having sufficient funds to pay for the resources or the highest bidder will succeeding in resource acquisition.

The third contributing reason, is that Eskom did not have technical expertise and experience in constructing these power-infrastructure capital investment assets. Most of the expertise that were involved in the design and construction of Matimba power station had left Eskom for better opportunities in another world power utilities and some have retired.

The fourth reason is that Eskom started looking for partnership in the world in order to assist in developing these capital power-infrastructure investments but did not conduct proper due diligence.

This is because there was no adequate internal competency to evaluate and adjudicate on suppliers'credentials.

In an nutshell, Eskom did not have capabilities and sufficient time to choose, but took the person who was available at that time. In this question another participant stated that should Eskom had sufficient time they would have approached contracting differently than the way it was conducted. In these investments, there were many packages when awarding contracts and too many interfaces. This was the high risk approach of procurement and contracting. These projects were split into various small contracting components such as having water purification contract, electrical contract and so forth. The respondents felt that this could have been assigned to one contractor who will have to understanding the sequence of events in delivering the output product such that water should be ready at the certain time or what component will need power in order to perform certain duties or vice versa.

The fifth reason was that there was inadequate stakeholders' agreement as almost all respondents stated that initially government intended to develop IPPs but there was disagreement in the terms of costing. Later the government who is the 100% shareholder of Eskom turned to Eskom at the 11th hour to demand Eskom to deliver these power stations within limited time-frames. This compromised adequate engagement with other stakeholders such as contractors, local communities, workers around the plant, ministers, local government.

A participant further stated that the historical approach had been leading to cost overrun and schedule delays due to poor management of stakeholders. This poor stakeholders' management led to unrest in the labor force and local communities. For example, one of the participant from Cape Town stated that in the case of nuclear, the resource availability on the nuclear regulator side such as South Africa Nuclear Energy Corporation (NECSA) was such that 30 days work ended up taking 100 days to get approval due to NECSA's limited resource availability. In such cases, engineering and project management made allowance for cost and schedule variance. This required stakeholders to be more realistic in understanding outside environment and build proper schedule rather than to have unrealistic completion date.

The sixth challenge was the need to comply with Black Economic Empowerment (BEE), local skills development and meeting the deadline. After eight years of being non-active in power station development, the contractors that previously worked in Matimba Power station had liquidated. Most of the experts had emigrated and others retired from construction of generation infrastructure projects. Eskom had to be rushed into delivering these projects with poor skills, inefficient upfront planning and improper risks identification and understanding, assessment of risk and lack of putting appropriating mitigations techniques.

This further included whether the organization intended to pursue capital investment in a Private Public Partnership (PPP) approach or Joint Ventures (JV). The possible PPP or JV was inadequate considering the time the due date completing these power stations. Another respondents stated that beside Eskom, most of the power utilities like to take shortcuts. In addition, this is detrimental and it compromises adherence to cost to completion. The example is that short cuts leads to inconsideration of matters such as force majeure (the natural disasters) that has to be included in the schedule. There was another participant who stated that not every risk is a threat as some brings some opportunities that has to be mitigated appropriately.

However the emphasis should be directed to proper establishment of Integrated Risk Management Plan which will look at the holistic view of the project management plan so that the all risks pertaining to project knowledge areas including development of the project could entail. These are among the reasons South African power utilities find themselves in liquidity position.

- **The second question expected the respondents, as experienced executives of the power utility to explain how the financial analysis such as IRR, ROI and NPV have enabled Eskom in realizing the investment benefits or profit that were forecasted initially during feasibility study.**

All seven respondents answered this question. Summarily, respondents responded by giving the context that it is the function of the investment committees to ensure that return on investments are realized. Contrary to that, it is not all power-infrastructure investments that are indeed for return realization as some other investments such as socio-economic development investments such as electrification are not driven by profit making.

Regardless of the above, respondents summarily stated that among challenges faced by power utilities such as Eskom in particular, is firstly to ring-fence divisions into Profit & Loss (P & L) centres. For example, if the generation division was running as the business on its own, it would have the profit and loss analysis and it would have the balance sheet. Another participant stated that regardless whether divisions are operating on their own, the real major challenge in South African power utilities is that utilities are vertically integrated. Unbundling power utility such that licensees such as generation, transmission and distribution, export and imports and pricing to run independently and work on attracting the foreign direct investment could be among pertinent strategic approaches.

This means that, as narrated by another participant, if a certain division was running independently but wanting to have capital infrastructure project, it would increase its CAPEX, but funding the project through its profit. This means that the division will fund that capital infrastructure investment through equities instead of bonds or equities.

"In the ideal world, when the CAPEX increases, there has to be an increase in the revenue income so as to be able to see what the NPV is. Eskom does not have the profit and loss centres in divisional levels, it becomes difficult to see which division is performing better than the others in terms of financial revenue income. The addition of one unit into the grid, makes it difficult to determine the revenue income that has been generated by each unit over certain time just because divisions are not running independently with their profit and loss centres". In other words, there is always an assumption that production from the new unit is making profit.

When the Medupi and Kusile started construction, there was no financial security, as the country was urgently demanding to have additional generation capacity. If power utilities were not state companies, there was going to be the need to financial assurance and security before embarking on such huge capital-infrastructure investment project.

Secondly, the respondents all stated financial models used as contributing to liquidity crisis faced by power utilities. In the case of Eskom, one of respondents stated there were different methods of assessing financial investment viability. Those with very long-life spans such as for generation have a different methodology of assessing financial viability compared to what Eskom Distribution and Transmission had. The example of these projects relates to the condition of the license such as in Transmission and Distribution division environment infrastructure. Transmission division has to build the infrastructure to ensure that there is power for distribution as that is the license condition. One of the respondents stated that regardless of the financial modelling, what is imperative is to look at the total cost of ownership of running that investment plant.

In other words, that is to include the capital-outlay investment requirement, operational and maintenance expense including the purchase of the fuel. Furthermore, what this participant was emphasizing was fruitless as it became eminent that the participant was implicitly stating existing financial models. One of the respondents used an example of capital investment made by distribution division in Kwa-Zulu Natal, lower South Coast area called Umzinto, in the informal settlement called Sanathan when entering the town.

The R15million capital power-infrastructure investment executed not driven by returns but by safety due to Electricity distribution license conditions, stipulations on grid code compliance and Occupational Health and Safety (OHS Act) that are required for compliance. These conditions enforce the distributor, or anyone given a license to supply electricity infrastructure or the machinery to ensure that it is in safe condition to the users or the public. Otherwise, failing to comply with these requirements, NERSA has the right to revoke the license, due to failure to meet the license conditions.

The other view, as presented by another participant, is that the realization of those return on those investments happens through tariff increase negotiations with NERSA. The benefits are there for the broader South African public utilizing electricity to enjoy. The investment expenditure in Sanathan and other related projects are not based on Cost Price Index (CPI) as it is the case in coal -infrastructure development projects, where investment is required because the coal increases at certain rate per annum but based on factors that drives their need to have them executed.

One the respondents stated that in the case of Medupi and Kusile, financial models were considered. The participant further stated that the decision to execute these projects was already taken. Eskom had to start construction in order to address power capacity constraints. This participant further stated that the lessons learnt taken from other these projects, including the international practices, is that the Eskom power utility negotiations with NERSA was limited on the MYPD discussions which allowed IRR of 0.5% by NERSA against the loan repayment of 10% interest rate. NERSA at that time had informed Eskom that they would not be raising an interest rate of by more than 0.5%.

This then became the crisis because Eskom never had another income stream to finance the shortfall cover of 9.5%. The NERSA approval was not supported by the IRR that Eskom submitted to make the investment to realize better returns. The concerning part is that Eskom submission should always include the CAPEX and OPEX to NERSA, even though CAPEX is higher than 0.5%, it becomes NERSA decision to approve tariff increases. Eskom currently facing the high debt book that cannot be afforded. If the approach was different, Eskom would have had a different costing and pricing model for Medupi and Kusile by sitting with the regulator upfront and agree on the costing and IRR that would support those projects.

The follow up question was further asked as to how this could be prevented in future. The participant stated that through the lessons learnt, the capital power-infrastructure investments are now strongly motivated through the regulator, unlike previously. In terms of the process, Eskom has to supply its assets and capital plans to NERSA in order to make price determination, although some of the determinations are based on parameters unknown to Eskom. The participant continued stating that on the newer investments, IRR is considered in details and engagement are done with the regulator, but it is still the regulator that will make tariff increase decisions.

The researcher further asked how effective is this MYPD process? The participant stated that it is surprising that the power utility, being the state-owned, has to make all submissions to another state-owned entity related to why there has to be tariff increase. Another state-owned entity will make the decision for another state-owned entity, without thorough consideration of related cost and impact to the South African government. The Eskom board of directors together with the

Minister of Public Enterprise will have to resolve this issue. The integrated capital power-infrastructure investment decisions are the function of Department of Energy, which is not on the opposition side of NERSA.

The participant used an example, looking at the IPP contract that has been signed down, the contract is signed with Department of Energy where the IPPs are getting the contract for R172/kwh and Eskom is paid about R0.87 cents/kwh. Further to that, the participant stated that Eskom prices are brought down by NERSA, not because Eskom is failing to submit proper price determination. This is the contradicting views with what Eskom is experiencing compared to what is progressing in the Department of Energy. In the nutshell, NERSA approves tariff price increases for Eskom and Department of Energy approves the prices for IPPs with the Power Purchasing Agreement (PPAs). These two entities NERSA and Department of Energy are both approving electricity prices, but the approach is completely different with the other one double the other one.

The researcher further asked if are there any models that could be utilized by Department of Energy to arrive at either integrated power investment decision or by NERSA to assume that Eskom tariff approvals were justifiable? There was no proper response on this except reverting to existing financial models and investment options as narrated by another participant as least to have cost, moderate costing and high costing. *In Distribution there use to be an investment state forms for projects, where if the wanting to extend distribution networks, there is an investment process to follow, looking at breakeven points, and Net Present Values (NPV) and looking at customer benefits. This is the same way when doing these big infrastructural projects such as Medupi, Kusile and Ingula. There is Levelized Cost of Energy (LCOE) that is supposed to investigate that. We have the biggest problem with that"*

- **The third question expected the respondents, as experienced executives of the power utility to share their experiences on how stakeholders contributed to the success or failure of capital power-infrastructure investment.**

In this question, the respondents stated various experiences related to stakeholders' contribution to the success or failure of power-infrastructure investments. It is imperative to state that all respondents have a strong belief that through stakeholders, projects fail and through stakeholders, project succeed. It is imperative to highlight that all respondents felt that in most of the failed projects, there is compromise of stakeholders' engagement. Amongst many examples made by various respondents, the researcher would present all.

One of the respondents made an example about the construction of Medupi power station. He stated that when they were augmenting the water system in Lephalale area, the success was that local

government managed to accommodate many of people affected by the development. In this, Eskom worked together with stakeholders to make sure that there was accommodation. Further to that through stakeholders' engagement, the town was equipped to make sure that it was capable of handling the extra volume of people.

On the negative side, when some of the units were completed, the appointment of contract workers was through a projectized approach, in other words, the completion of the project meant that they had to be demobilized. It is where approximately 2000 people started to work very slowly, as they did not want to lose employment. Once the job was complete, people started conducting in protest outside the gate and that impacted on those that were still working.

The same participant made the comparison with Kusile work localization. He stated that failure to do proper stakeholder engagement led to community protest. The community protest was related to job opportunities. The local community was saying their children and husbands were not working, whilst the project was running in their backyards. The participant stated that the community argued that the contractors were giving employment to people that did not even reside in the province, as some were even residing outside the country.

The participant reverted to Medupi and continued stating that the success of the majority of projects depend on how stakeholders' benefits from that project. He stated that in Medupi, the government departments such as Water and Environmental affairs had to do their due diligence in making sure that impacted species were protected. The same issue with the process for the water use license, it was followed properly and an Environmental Impact Assessment (EIA) was done accordingly. In the case of Medupi and Kusile, birds and snakes had to be removed properly without increasing bird mortality.

The participant stated that without stakeholders it would have been challenging to have to comply with all those requirements. The success was on cautiousness that most of the infrastructure projects are happening in community vicinity or in the environment where its existence will require stakeholders' participation.

There is Public Finance Management Act (PFMA) requirement to follow and requirements from Department of Trade and Industry (DTI) to follow. All those requirements are derailing the project when all these requirements have to be met, such as for ROI, empowerment of the stakeholders, environmental compliance requirements. The participant continued stating that other than the community, other external stakeholders include World Bank and Central Application Fund (CAF), contractors, and politicians played crucial role. The participant stated that the role played by funders is that of funding Eskom whilst its balance sheet was under pressure. He stated that it was the

challenge to get funding for projects such as nuclear and coal infrastructure but getting the funding for projects such as power lines has continued to be successful. The participant stated that the improvement is that investors have now managed to have influence on how governance be conducted.

Moreover, there were Eskom internal stakeholders such as divisions more particularly transmission, project engineering, environmental department that are a crucial part of the value chain process of power-infrastructure development.

On the negative side pertaining to the stakeholders, various respondents stated different experiences, but the main theme included complexity in meeting all expectations that politicians such as Mayors and Ward Councilors have when power-infrastructure capital investment have to be executed. All respondents stated that in the number of executed projects the primary expectation of politicians is not to put the effort on making power-infrastructure investment successfully executed. They stated that mostly in the mind of the politicians, it is about how they can benefit or enrich themselves and further make their names to be a lasting legacy. The respondents felt that it is typical of such stakeholders that have negative contributions toward the project successful completion, it was not successful for that stakeholder's benefits. They hold the power utility to ransom in most of the times. The unfortunate issue is that this leads to construction stoppage. The contractor continues to claim for the standing time, due to the resources in disposal including trucks that they are renting. The money that is spent is wasted instead of going into physical construction of the power-infrastructure investment. This is continuously getting worst requiring local and provincial government to intervene as this is impacting to everyone through economic growth.

- **The follow up question was asked "what do you think could be done to minimize this behavior of politicians?"**

The respondents responded by stating that the main challenge was that there was a very high frequency of changes in government due to corruption. He stated that "*the MEC that you may have had the good working relationship with, might not be there tomorrow because of factional fights and investigations that were underway"*. The preventative measures to this could be through stability in government and there has to be the provincial ownership of infrastructure development by the ruling party, African National Congress (ANC). The return for the ANC in this is in terms of economic growth and employment of the people. This is in line with ANC manifesto related infrastructural development, economic growth to leverage skills development and creation of job opportunities. The national government has to ensure that the provincial Members of the Executives

(MECs) are taking full ownership of power-infrastructure developments as Mayors and Councilors have their own self-enrichment agenda.

What specific examples would you like to make where stakeholders led to the failure of the project?

One of the respondents responded by stating that the inadequate stakeholders' engagement in Kusile led to the realization when they were already in construction that the site was for Anglo-Boer war fought in 1900 to 1902. It was later discovered that there were many battles raised in that area such that there were unmarked graves.

A participant stated that it was very common on the daily basis to find the graves with two, three or even more bodies when digging. The challenge was then on the identification of those people, whether they could be relocated and what were the procedures that had to be followed. In the case where the identification was that, the corpse was from the indigenous black African race, there was a very specific traditional ritual of exhuming the body and there was specific way of translocating the body from one grave to another grave. This delayed construction and attracted cost increases that could had been considered had stakeholders engaged properly.

One participant that stated that part of the delay was that Eskom signed the contract with an international contractor and started to push for work localization. The international company stated that it was the only company with capabilities of doing the engineering designs. In compliance with the South African BEE requirements, the international company then decided to subcontract most of the construction to local South African companies. The participant stated that almost 90% of those South African construction companies never had any idea of the monetary value of what they had tendered for. This led to almost 90% of those local construction companies to run into financial liquidities. Some of those companies had to some financial reserves, which were depleted. Although there was strong emphasis from one participant that local companies had to benefit, another participant stated that most of the local companies spent a lot of money, but unable to complete work and were liquidated. The participant rounded up this discussion by stating that large projects are not beneficial to local South African companies in terms of the rand value beneficiation.

Another follow up question regarding how stakeholders' relationships can be improved such that it prevents causing schedule delays and cost overrun was asked. There were various versions of responses from respondents, some responded by stating that writing the pledge agreement in the upfront planning could assist, another participant stated loyalty and transparency should be encouraged and the other stated that all stakeholders need performance compact, related to their roles that they have played during delivery of power-infrastructure.

One participant was greatly emphatic on transparency between stakeholders and made an example about court case in Cape Town High Court between South Africa and USA company called Westinghouse. In that court case, the participant stated that South Africa was to procure 9600MW nuclear deal. Some of the international companies tendered for the RFI. Later, South Africa awarded the contract to Rosatom. The participant stated that in terms of Supply Chain Management, the award could be made once quotations have been submitted. It is for this reason Westinghouse challenged South Africa to court stating that the procurement process was not properly followed. In this, the list of stakeholders included government, non-profit organizations and international experts. The officials from South Africa was to ensure that there was loyalty and proper transparency during stakeholders' engagement. They were supposed to develop the stakeholders' management strategy and associated risks.

Westinghouse was claiming that South Africa did not follow the Supply Chain Management process in awarding the nuclear deal contract to the Russian company (Rosatom). The court ruled in favor of Westinghouse stating that the nuclear deal between South Africa and Russia was not procedural. This participant further made two other examples related to transparency. The first being the construction of 2010 World Cup and e-tolls in South Africa. The participant stated that when government of South Africa wanted to invest in soccer infrastructure, all stakeholders were engaged. He continued stating that it was not the same approach when e-tolls were constructed. In both these projects, government was the central player, but they had different community responses. The participant concluded by stating that the main reason was that in 2010 soccer stadiums, there was transparency and in e-tolls there was inadequate consultation, if there was any at all.

- **The fourth question expected the respondents to broadly indicate what systems or processes, as experienced executives of the power utility, they would have liked to re-model differently in order improve capital power-infrastructure investment efficiency.**

There was one participant who refused to answer this question, as part of the ethical clearance conditions it was welcomed. Summarily respondents stated various things such as review of investment costing system. The current cost-estimating tool excludes assumption of penalties and contract variations due to claims to make better determination where the project cost will end. The respondents stated that what is required is the integrated cost-modeling tool with schedules.

The respondents stated that the second thing is to improve the planning, and not repeating how the construction of Medupi and Kusile power-infrastructure was approached. Some respondents acknowledged that Eskom has implemented PLCMs processes. They have accepted that this improved

and added value as the better model compared to the previous approach that drove uncertainty to cost completion.

Thirdly, respondents stated there was improvement in the requirement in contracting strategies. The view from respondents is that contracting has to be on the activity management instead of output or delivery management. Respondents felt that this could prevent challenges that has led Eskom to pay claims that could had been prevented. For example, the splitting of designs to be conducted by consultants and project management and construction to be done by the contractor who will again charge for project management, is one of the challenges that require changes. The turnkey approach is one of the best approaches that will yield results. The current approach on multi-contractors in mega approach results in a tedious exercise dealing with multiple contractual issues with various contractors instead of dealing with one contractor.

Fourthly, the respondents felt that there has to be fast development of Brazil, Russia, India, China and South Africa (BRICS) bank and South Africa's state bank as they have delayed. They stated that it was going to be another way of getting funding through local institutions. For example, worldwide there are anti-nuclear organizations, same as in South Africa. If there was going to be nuclear power-infrastructure development, delays as the results of funding would had been avoided through approaching suitable banks for such mega infrastructure development. He continued stating that it was going to be difficult in future to obtain foreign investors for nuclear deals, even if there will be, they will come up with high interest rates.

Fifthly, the respondents stated that Eskom previously in Medupi and Kusile changed the project management system, such as costing system, the planning system and other related project management systems whilst the project was in progress. Respondents stated that Eskom should not have changed management tools whilst the project was in construction. In many cases, changes affected data transfer from one tool or software to another which created challenges that the information was also missing, improper alignment leading to some other tasks to be done manually. According to respondents, Eskom later realized that this was complicating matters instead of making project management life easier.

The respondents mentioned the sixth thing as the re-modeling of knowledge management system in Eskom and the country. One of the respondents stated that most of these consulting companies including those used by Eskom have large research departments, and any power utility can present the problem today but tomorrow the consulting company will have the big power-point presentation with solutions for the company. This participant continued to state that this information is easy to put together due to years of tacit knowledge banked and continuous research. Respondents stated that it is the same case with Eskom or all other power utilities, people that developed Kusile, Medupi and Ingula have tacit knowledge that will have to be shared.

The organization must develop the platforms to share their knowledge including different challenges experienced between mega power-infrastructure investments. These platforms should not be for incentivizing people to share information but to ensure that there is knowledge share among the people regarding their discipline. This should not be limited to design matters but must also include construction resources as well. It was some of the respondents' strong feelings that, what drives cost high is where there is a high magnitude of the unknown. When the unknown is a major risk, the related cost is high. When limiting the magnitude of the unknown, the risk and cost becomes limited.

The last thing that respondents were concerned about was the contracting strategies that they believed was exposing Eskom into more contractual risks. Respondents stated that contracting strategies was supposed to make sure that it minimizes the risk to Eskom. The respondents stated that the current contracting strategy was conservative to be applied in such mega-infrastructure development project.

The majority of the respondents believed that the best is to consider turnkey approach when doing contracting. In this approach, the risk is borne by the supplier instead of the utility (buyer). This approach can work even in the distribution environment that is currently designing the project internally or using the consultant but appointing an external construction contractor.

- **The fifth and the last question expected the respondents to broadly indicate what they, as experienced executives of the power utility, think Eskom should do to recover payment or transfer money from neighbouring counties to South Africa without compromising diplomatic relations.**

The respondents stated that countries have bilateral trading agreements. Eskom only trades with countries where South Africa has agreed to trade with, in this there has to be sales agreement present. The utility has the right to institute sales agreement by first warning the country that if that country does not pay, Eskom will reduce the supply of power. When country refuses to pay, the power utility will have to switch the country off.

One participant stated that Eskom has tried to cut off Zimbabwe, but politicians got involved claiming that cutting off Zimbabwe was going to plunge the country into other unintended chaos. Some respondents stated most of the neighboring countries are willing to pay but their main challenge is unavailability of the foreign exchange currency in their own country.

The complexity in Power Purchasing and international trading agreement, include the trading currency. In the country such as Zimbabwe, economic sanctions may have had foreign currency restrictions. In

addressing this challenge, approximately in year 2000, Eskom started to propose to have an Independent Bank account in that country with a power utility and that country being the signatories.

This allowed both signatories to have the view that the other country was servicing the account payment. The limitation on this was the foreign exchange, which continued to be the challenge. This therefore meant that regardless that they were paying in that Independent Bank account, there was still revenue income shortfall.

Another participant, cited the then Eskom Group Chief Executive Officer, Brian Molefe, stating that due to political changes, it was going to be better to get the Government Guarantee that the money was going to be paid even if there was a change in the ruling party. The challenge in the provision of cross border essential basic services that could impact the country including society, there will always be that political interest.

This is different than selling other services that are not impactful but most of the countries are willing to pay. Further to that, when looking at companies such as MTN and Woolworths where they faced various challenges in receiving their money. Therefore, diplomatic regional relationships including in that of SADC, need to drive corporation growth. There are many dialogues in other regions such as European Union (EU), Organization for Economic Cooperation and Development (OECD) pertaining corporation compared to SADC or African Union (AU).

South African power utility or any state-owned companies doing business in the continent, the structuring of bilateral trading in the regions should be driving economic cooperation and growth. Former President Thabo Mbeki introduced African Renaissance which was the aim of improving cooperation in Africa. African Union (AU) seems to have lost that drive, until that is done, repatriation of money after rendering service in some of other countries continues to be the challenge. Some of the companies including Eskom has done work in other countries but failed to be paid.

Further questioning to respondents regarding how the power utility can overcome such situations were posed. The response from some of the respondents was in many countries the best model is when two countries have an agreement about the work that will be done. Once the contract is signed related to the scope of work and the amount to be paid, these two countries will have to open the trust account with an independent bank based in the foreign country such as in London and New York. According to that participant, there has to be a payment agreement reached based on achievement of a certain milestone before payment is released to the supplier together with the evidence and signatories.

This eases the supplier that the money is already secured for the work that will be undertaken and they are clear that when the job is done, they will receive payment. However, power utilities such as Eskom need to be cautious as it is not all countries that want to have that route pursued, as they may not be

having necessary funds. Countries that do not have sufficient capital will approach funders such as World Bank or Power Africa to obtain the funds as a form of security and they issue the Guarantees that when the job is complete or at activity levels, the contractor will be able to receive payment for the work that is done. In this arrangement, it is normal that the bank would appoint an engineer or the project manager who will ensure that things runs smoothly, when the job or the activity is complete, payment will be processed by the project manager. This can also be done with another country acting as the security.

Lastly, the respondents cited Ekurhuleni Metropolitan in Johannesburg; that they have an interrelated linked system for electricity, water and rates. This means that inability to pay for any of the services, means service restriction and eventually disconnected electricity or evicted from the house. The main issue in capital infrastructure investment is the lack of Integrated Risk Management Plan in South Africa.

This means that when starting the project in a foreign country, there has to be the insurance cover that covers both the seller and the buyer in case there is issues such as foreign currency fluctuations, bankruptcy by either party, global sanctions while the contract is active, and global recessions.

5.5 CONCLUSION

This chapter has been able to provide both quantitative and qualitative data analysis. Quantitative data analysis was further substantiated with pairs of selected questions used to conduct regression analysis. Further to that, the chapter indicated that amongst other things that are the challenges of South Africa's capital power-infrastructure investment are improper upfront planning, improper due diligence, lack of good corporate governance, inadequate scope leading to cost overrun, and poor contract management strategy. Furthermore, the challenges included resource unavailability, improper supply-chain management policies, and other challenges that are discussed in detail in the next chapter. The selected questions used on regression analysis were research objective questions.

The chapter indicated that the above challenges are continuously leading to unrealistic prediction of deadlines for delivering completed projects. The next chapter comprises of the broad discussion of the above research findings.

CHAPTER 6

DISCUSSION OF THE RESEARCH FINDINGS

6.1 INTRODUCTION

The aim of this chapter is to present a holistic discussion of systems thinking in reviewing capital power-infrastructure investment. The strategic nature of systems thinking is osmotic, which may assist in the fundamental development of understanding micro-causalities involved in power-infrastructure capital investment challenges.

The chapter further presents statistical regression analysis results to facilitate discussion related to the group of consolidated questions that were used to answer the main research questions in section 1.6. It further presents the application of system thinking as one model that could be used to determine challenges of power-infrastructure capital investment. Lastly, the chapter presents investment selection techniques.

6.2 DISCUSSION OF THE RESEARCH FINDINGS

In this chapter, the consolidated quantitative data together with the feedback received from the participants in the qualitative research section to provide answers to the main research questions are discussed. Firstly, the quantitative data is presented first, collected from engineers starting from 2 years to 30 years working experience in Eskom. Secondly, the regression analysis related to how participants have applied their logical thinking during responding to the questionnaire. Lastly, the qualitative data follows collected from engineers with at least 20 years in Eskom holding executive positions.

6.2.1 Challenges regarding development of power-infrastructure capital investments

In the questionnaire there were five questions developed to answer the above-mentioned research question. The first question aimed at determining whether or not the scope in capital power-infrastructure investments is adequately defined during the concept phase. If the scope is not adequately defined it would lead to scope variations during the execution phase. Another question was aimed at determining whether or not the cost basis does fulfil the entire capital power-infrastructure investment requirement or not. Furthermore, there was a question aimed at determining if it there is a possibility that resources are not adequately stipulated during early stages before asset construction starts.

It is appearing that in all these questions, the combination of strongly agreeing and agreeing outweighed neutrality. It further outweighed disagreeing and strongly disagreeing. The majority of the participants (85%) answered the scope question at least agreeing that the scope is not properly defined. The

participants (72%) that answered cost question at least agree that it does not fulfil the entire project cost requirement.

Some of the participants (68%) responded by stating that resources required for construction are not adequately stipulated accordingly. The fourth was the question aimed at raising the discussion related to stakeholders, in this question, participants (70%) responded by stating that stakeholders' disagreement or game power was amongst some of the challenges leading to power-infrastructure capital investments. The fifth which is the last was aimed at raising the discussion on the fact that participants (75%) believe that contractors manipulate contract in order to make more money.

On analysis between scope, cost, resources, stakeholders and contract manipulation, it was obvious that participants believed that inadequate scope definition was and is still the main challenge. In most power-infrastructure capital investment projects, the use of external resources, the contractors, has minimum risk of cost overrun to them. In power-infrastructure capital investments, should the contract management strategy be used such that the designer and contractor was the same engineering company, contractors were going to borne the risk. Projects are all unique to each other, presenting various complex challenges and requires unique contracting challenges.

The response received from engineers was not fully convincing as such, as it had elements of being contrary such that 6.02%, 10.13%, 13.75%, 11.25% and 8.86% of neutral participants and 8%, 17%, 18%, 17% and 15% of participants in disagreement respectively for each question. This is a significant number that is worth pursuing understanding instead of overlooking. The high number of participants that disagreed created a need to explore the question further, in order to determine what the driving reasons behind their disagreeing notion could be. In this, there was no detailed understanding except the follow up on some of the engineers that participated in the study to determine what could be the rationale behind some of those that disagreed.

On the follow up discussion, there was an assumption that was developed that some engineers that responded as neutral in answering that question may have been the engineers that have never had their designs executed to physical construction completion. This is because they were new recruits of engineers (at least two years experienced) sponsored by Eskom on their academic study and entered the industry on semester basis for work experience. It would be very interesting to listen what could be the rational, in case the experienced engineer responded by saying neutral or strongly disagreeing. The possibility that there could be experienced engineers that could have disagreed was tested, but there was no such indication that some experienced engineers may have answered with disagreement.

The researcher believed that these participants based they responses on the application of delay damages due South African labour laws and complexity of stakeholders specifically the politicians. The example

of this is Medupi, Kusile and Ingula pump storage where the construction of capital power-infrastructure asset stalled due to political interference. Even during construction, it became evident that contractors influence labourers to protest in order for the project to stall and they claim for delay damages

The challenges faced by utilities in capital infrastructure investments are better explained by the challenges that were faced by Eskom in the construction of Medupi, Kusile, and Ingula power stations. The first challenge that Eskom faced and is still facing is the fact that the actual skills and capabilities of constructing the power station are lying outside Eskom. There is evidence that the main reason for this is emigration, passing away, or retirement of skilled engineers. When the need came for Eskom to design and construct these three powers stations, the power utility found that it had to rely on foreign skills for design and construction of these power stations.

The shareholder, that is the government of the South Africa, is the main contributor to the skills shortage in power utilities as they aimed at developing alternative energy mix. Following the construction of the first power stations many years ago, there was no further power station design and construction skills development. This led to the issue of skills shortage in power stations design and construction. It is worsening in municipalities. There is no evidence that there are government initiatives for such skills development, which is particularly important as most of the coal fired power stations are coming to an end of their life spans starting from year 2023. This means that unless power station design and construction skills are adequately addressed, it is most likely that the South African power utilities will continue facing skills shortage in power-infrastructure design and development. In other words, this means that Eskom should have started sourcing resources for the replacement of power stations that start reaching the end of their life span in year 2023, and as early as year 2014.

In the construction of Medupi, Kusile and Ingula power stations, the skills were not only required in the power station design, construction and project management but were also required in investment committees to guide the investment committees towards adequate investment. In other words, such skills in the committees would have made sure that adequate scoping, appropriate costing is baseline properly, risk of inadequate resource requirements and the impact of stakeholders were properly discussed. It seems that such skilling of investment committees was not done. In other words another challenge faced by Eskom in capital-infrastructure investment is lack of skills on the part of investment committees.

The issue of skills shortage is continuing, and it is worse in municipalities. This means that unless power station designs and construction skills are adequately addressed, it is most likely that the South African power utilities will continue facing skills shortage for generation power-infrastructure design and development. The proper tender process for design is by foreign companies is estimated to be about 4

years and construction estimated to be between seven to nine years. In other words this means that Eskom should have started sourcing resources for the replacement of power stations that start reaching the end of their life span in year 2023, as early as year 2014.

The power station design, construction and project management skills were also required in investment committees to guide the investment committees towards adequate investment. This resource would have been less costly for Eskom than what it ended-up actually costing to build Kusile, Medupi and Ingula power stations. This resource would had been the external consultant acting on the full capacity of Eskom or the experienced contracted engineers working with Eskom as employees. This would have solved more problems as it is known that mega-infrastructure projects are large and complex. The inability to have this skill competence within the committee meant that stakeholders engaged and approved capital investments without proper understanding how cost derivatives were reached.

It should be noted that there are also external stakeholders involved in capital power-infrastructure development. In most power-infrastructure capital investment projects, it is mostly community, business sector and politicians such as Councillors and Mayors. Government departments are required for regulatory process, financing and licensing.

In this study, the participants made it clear that there was improper planning from power utilities as well as from government side to ensure adequate investment within the budgeted cost. In leading towards being able to provide an answer to this question, the considerations and acknowledgement of critical factors related to cost basis requires understanding. In most of the investments, the cost derivative is from the actual Bill of Material (BOM), with the exception of critical and complex factors that are leading to cost overrun. Cost engineering software that engineers are using assumes linear cost escalation. The example could be the contract that is signed in foreign currency. Example, take the contract that is signed in US dollar, the rand volatility causes frequent fluctuations and it is worse when the governance committee has its incompetence and its bureaucracy. The delay in the approval process can be experienced. In contrary, even if governance committee had approved variations , there is another department that will have to ensure the holistic or national capital budget review and capital system challenges whilst the contractor is standing on site. This will mean that the contractor has to submit another standing time claim. This further escalates the cost from the initial submission and the need for revision again and continues to dominate and frustrate investment committees.

Other challenges include availabilities of commodities such as steel and copper for construction of power lines. The shortage of steel and aliminium due to Chinese emerging steel market and shortage of poles, transformers exercibate construction delays leading to construction cost overrun due to cost for delay demages. The shortage of steel means that the contractor will stand unnecessarily and the power utility will have to compensate the contractor for standing.

In the global perspective, the research has led to an understanding that the cost overrun in South Africa was consistent with the projects' cost overrun as experienced by developed countries when developing any form of infrastructure. In power utilities, amongst some of the challenges is the regulation of retail section without making proper regulation in the primary energy. In making a domestic example, it will be regulating Eskom transmission and distribution without proper regulation of generation division. In other words, it will mean that the retailer is buying expensive power generated from the non-regulated division but sell it at a regulated price which is already making the loss. The example made can be related to the cost of coal in South Africa that is costing above industry norm. It was stated earlier that Group Chief Executive of Eskom has alluded to the fact that Eskom is not structured to be profitable.

Further to that, the resource availability is among what stakeholders expect to see when developing capital power-infrastructure. The question is more determined during the planning stage of capital power-infrastructure development. For example, when planning to construct 100km long transmission lines, there has to be a base estimation how many resources will be required to achieve construction completion by certain date. The detailed analysis and the model related to resource and cost baseline estimation is outside the content of this study.

Al-Hazim et al. (2017) stated that 82.3% of construction projects experience cost overrun. For example, installation of the overhead oak power conductor will be R6.50/metre. It excludes the terrain and poor access where the conductor will be installed. It does not consider inflation after years. It is therefore important to consider what is happening in other countries related to costing. Further global discussion on this has revealed that construction projects that are in Jordan and Palestine experienced cost overrun due to the following reasons:

- Inadequate scoping for terrain requirements;
- Improper planning for possible inclement weather conditions;
- The delay in governance committees for approval of changes;
- The unavailability of human resources to conduct work;
- The design change requirements;
- Poor cost estimation; and
- The market conditions.

The relevance of these above-mentioned atrocities aligns to what South African power utilities are experiencing. South African transmission power lines traverse long distances such 1600km from Mpumalanga to Cape Town through undulating rocky, muddy and sandy terrains. The reduction in cost to complete variations require improved base of cost estimates. The existing costing models are such that they can assume linear costing as if the terrain is similar from Mpumalanga to Cape Town. It is

normal to assume that there is no person who could walk 1600km from Mpumalanga to Cape Town, but on the other side the cost variance is also unacceptable.

The season for inclement weather is known with South African Weather Services (SAWS) announcing weather of daily basis, however there is still an improvement required for long weather forecasts in order to improve on cost overrun. The results in Table 5.2, related to cost, are also driven by inadequate scope definition, improper construction to complete schedule and inadequate resourcing for infrastructure development.

In this discussion, acknowledgements should be made that power-infrastructure investment is highly capital intensive such that globally there is a declining investment whilst power demand continues to grow. Some of the countries, more particularly those with low income per capita, have opted to import power from neighbouring countries instead of developing their own infrastructure. The reason for this the difficulty in raising capital and cost overrun containment. The Minister of Public Enterprise, the chairperson of the Board of Directors of Eskom and all the Eskom Executives have declared on public that the cost overrun on Medupi, Kusile and Ingula have been escalated by the scope that increased from initial plans.

In contrary, further discussion has been as the result of the challenge with over-power importation. In this discussion, cautiousness should be made that importation leads to inability to grow domestic power capacity and contributed to under skills development. When the exporter's demand grows, the international market supply becomes the priority for discontinuity of supply. In a nutshell, the domestic power utility becomes incapacitated to supply its market with its own existing infrastructure. The example of this was the collapse of the Mozambique Direct Current (DC) supplying South Africa in 2019 due to inclement weather. South Africa faced high frequency of power shortage. The questions raised was related to what was believed to be the excess power in the country, and if there is still heavy reliance on international import.

Further to that, in this discussion, it is imperative to state that another reason leading to capital power-infrastructure investment is to spend money on over-sizing and globalization of the power utility in competition with the international trends. In this, it includes ICT infrastructure and policies. It also includes the usage of international companies to restructure the company whilst it is still developing and unable to enforce its own revenue income and stability. The discussion related to inability to manage technical losses and illegal connections, meter tempering and meter bypass is amongst the challenges.

International Energy Agency (2018) found that in the continent of Africa, the developing countries resonate but slightly differ from developed countries. The reason for this includes the extent of power-infrastructure development between developed and developing countries. Chapter 3 Figure 3.5 depicted that South Africa has the leading excess in Africa in terms of infrastructure development. Africa is faced

by shortage of power-infrastructure investment. The reason for this shortage includes the fact that capital infrastructure investment is capital intensive whilst countries in Africa are all developing.

The majority of African countries are failing to collect tax to fund themselves hence reliant on raising debts. The reasons for this include the lack of enough ICT infrastructure for power system management and for tax collection. The lack of power-infrastructure in the African continent has resulted in the poor regional integration, as there is a huge backlog for infrastructure development. There is a major investment requirement in all the power pools for all regions in Africa.

In the case of South Africa, power utilities are facing a high frequency of executive changes due to various reasons. This compromises long-term planning. The development of new long-term strategies has always been the practice from most of the executives in power utilities, as they always like to develop their own legacies instead of pruning the one developed by their predecessors. In that process, the focus on skills development is compromised and becomes the continuous ripple effect.

South African power utilities are regulated in terms regulation act of 2004. This regulation has kept power utilities just above liquidity status. The focus has been in Eskom as financially embattling power utility but power utilities in small towns such as Harding in uMziwabantu and KwaDukuza municipality in KwaZulu Natal and Bizana town in Mbizana Municipality in Eastern Cape are in dire financial deficiency. The population growth, the housing growth and industrial growth are facing unsafe dilapidated technology that is prominent for public fatalities including child electrocution.

South Africa has poor credit rating, meaning that it will be expensive for South African power utilities to raise debt. South African government, as the shareholder becomes the bond guarantor that money will be paid back to the investor. Even if the cost of borrowing or the interest to World Bank is 10%, South African government, being the shareholder or the bond guarantor has not cautioned NERSA when approving 0.5% tariff increase rendering power utilities to run at a loss of 9.5% per unit charged.

This has led to power utilities to fail to attract foreign investors, to continue being reliant on the shareholder to bail it out of debts or liquidity crisis and unable to fund backlog of power-infrastructure investment. Moreover, South African government introduced IPPs. It is imperative to discuss that there is similar consistency with the global trend, of heavy regulating the retailer whilst the wholesaler is not regulated. It was stated in the literature review chapter that coal is not regulated, same as the cost per kwh charged by IPPs at R2/kwh and sell it R0.80/kwh. This trend has led globally that power utilities function like the roller coaster. This is the direct cause leading to power utilities poor financial performance. The reason leading to this, goes back to the composition of investment committees, whether on the shareholders' side or in the side of power utilities. Mostly as stated in the literature

review that power utilities are behaving like the roller coaster, is influence by inability to interpret and digest information. It was stated earlier that among causes for this is the lack of relevant or specialised skills or advisory agent to assist investment committee, which is most of the times dominated by business general skills (such as a Masters in Business Administration, MBA) to make meaningful decisions.

Unless there is change that brings good working-corporation between stakeholders, power utilities will continue facing capital investment challenges. Some of the stakeholders, such as business and residential customers, have firm believes that power utilities are in this dire financial situation due to inadequate tariff restructuring. Residential customers including townships such as SOWETO believe that their tariffs are structured to subsidize business sector. This inculcate non-payment of electricity services, whilst the business sector argues why they have to pay for residential consumption. Some in the business sector believe that tariffs are expensive due to corruption.

Lastly, the inadequate country's supply-chain management policies promote the usage of local skills. The inadequacy with this policy is that it does not enforce foreign companies to ensure skills transfer to the local companies. The lessons learnt from local companies that were providing services during the construction of Kusile power station should be the case study for future generations. Most power utilities do not develop project intelligence tools that will assist in successful execution of capital power-infrastructure investments. This is to say that when building the 1km of the power line, what resources will be required costing at what rate. The intelligence should include the basis of estimation for resources as well as costing. In this discussion, it is imperative to state that the reason for the significant number of participants that either were neutral or disagree could not be ascertained. It is therefore likely that participants had beliefs such as those expressed by Hansford and Barnes (2013) on NEC 3 documents, where they stated that the New Engineering Contract 3 (NEC3) designed to enhance project performance without waiting for something to go wrong. The study conducted by Wright and Fergusson (2009) in the case of Meridian Energy in New Zealand using New Engineering Contract (NEC), Engineering and Construction Contract (ECC) and Suprapto, Bakker, Mooi, Hertogh (2016) who studied the application of various contracts used globally. In the case of Meridian Energy, the application of NEC ECC contract proved to be more beneficial to the Meridian as the client, for all types of contracts.

Power utilities in South Africa have had many contractual disputes ending in courts. In most of these disputes, contractors win resulting in power utilities having to pay including legal costs. The most common contracts used in power utilities are New Engineering Contract (NEC) and Fédération Internationale Des Ingénieurs-Conseils (Fidic), which is the international federation and standard for engineers and construction companies. Both these contracts allow for risk agreement and open communication regarding progress in construction sites. However, suppliers that are operating

internationally such as those that were building power stations, manipulates the labour laws in order to benefit extensively.

It is imperative to discuss that as Suprapto et al. (2016) stated that no contract is better than the other when it comes to project performance and management of cost overrun and schedule. They stated that the influence in construction performance is by relationship between the contractor and client, the agreements they reached and risk management.

6.2.2 The impact of timeous payment that debtors have in power-infrastructure capital investments in South Africa?

There were five questions to answer the above-mentioned research question. Amongst questions consolidated to answer the research question was the first question that was aimed at determining if there is a possibility that diplomatic relations with the neighbouring countries, could be having an impact in the revenue income for domestic power utilities. The second question focused on the impact played by cross power purchasing agreements. Furthermore, the third question leads to the discussion to determine the impact of switching-off power to defaulting townships such as SOWETO and provide alternative energy supply to reliable paying customers as the way of improving revenue income for power utilities. The fourth question is about the impact of timeous payment that Large Power Users can have. The fifth, which is the last discussion, is about appropriateness of fine amount that power utilities charge to defaulting consumers.

Earlier in Chapter 3, the study revealed that South African power utilities are vertical integrated towards government, as 100% shareholder. It was also stated that in the African continent, 45% of power-infrastructure is from South African state-owned power utility, Eskom. In all questions related to answering the main research question, the majority of respondents responded by showing agreement(s) regarding all questions raised. This is to say that most of the participants (57%) believed that in order for power utilities to move from debt to equities, the diplomatic relationship with the neighbouring countries should not compromise the revenue income of South African power utilities.

When South Africa, was going through political violence, some of the South African leaders went into exile in neighbouring countries. This established strong diplomatic relationships with these countries, which include but not limited to Zimbabwe, Swaziland, Angola, Botswana, Lesotho, and Mozambique. The majority of these countries are in the SADC region and they have a backlog in infrastructure development.

Yelland (2015) stated South Africa is the leader in the developing countries in the installation of prepayment meters whilst United Kingdom is the leader in the developed countries.

In all these countries, there are various reasons why each utility installed prepayment. Some of these countries do these instalments to reduce default payment, while others have predictions of revenue income and possible control electricity demand that will be required and improve safety that is always compromised during bypassing meters.

Eskom charges a fine of R6052.60 for the first offense to the consumer if a tempered meter was found. However, the average payment for the consumers with 60A breaker in their residential property can be at least R2000.00, amounting to at least R24000.00 per annum. Power utility officials can find the meter tempering even more than 5 years after it occurred. In most of the high-profile suburbs such as Umhlanga in Durban, Sandton in Johannesburg, and Chase Valley and Montrose in Pietermaritzburg, consumers pay an average of R5000.00 per month. In the case of Eskom, when the consumer is caught having bypassed the meter again, for the second time the charge is increased to R12 105.30. In this instance, Eskom normally removes the electricity infrastructure.

Research in Margate, which is in the lower south coast of KwaZulu Natal, it was discovered that there were consumers that have lived there for more than 10 years with bypassed meters and not paying for electricity. Although there are contractors that are doing disconnections, their scope is as per non-paying accounts from the Eskom billing system. Renting the property means just occupation into the premises; while it is only when the tenant opens the electricity account that the tenant will be traceable for consumption and payment. Some consumers in the area were not owners, as owners lived abroad, leaving the houses without attention, those vacant houses become home for the jobseekers in the area. In some other houses, the owners are deceased, and stranded families occupied the house but cannot open electricity account as they will be required to produce proof of residence, such as a form of rental lease.

The comparative analysis on penalties paid when bypassing the meter in Eskom was done to that of Mhlatuze Municipality in Richards Bay, which is in the North Coast of Kwa-Zulu Natal Province in South Africa. According to Khanyile (2018), who is the former Manager in Mhlatuze Municipality, who resigned in June 2018, the meter-bypass penalty charged in Mhlatuze Municipality was R5000.00 when caught having bypassed the meter. The difference with Mhlatuze Municipality is that they also estimate what the consumption for the last three years to determine what could have been the revenue lost. It then becomes the responsibility of the consumer to submit proof disputing what could be the most likely consumption and also by stating when exactly when they bypassed the meter.

The challenge in terms of the South African law, anything stolen should be proven in terms of being stolen. There is no restriction in terms of conductor purchases, as anyone can purchase conductors and cables and reconnect himself or herself. The continuity of electricity supply is the responsibility of municipality in terms of By-Laws.

In substantiating this, a review of the High Court case No CASE NO: 1477/2013, 1778/2013 and 1482/2013 that was in 2013 in King Sabata Dalidyebo (KSD) Municipality in Mthatha, Eastern Cape Province, South Africa was done. The applicants had done illegal connections then KSD Municipality removed the illegal infrastructure and therefore there was a discontinuation of supply to the premises. Then the applicants took the matter to court arguing that illegal connections are rive in the area, further stating that almost every business and residential supply is illegally connected.

The applicants argued that it was the responsibility of KSD municipality, in terms of the By-Laws to ensure continuity of supply to the business and at the same time deal with illegal connections if they pose safety risk and contributes to poor KSD municipality revenue income. The court ruled that it was constitutional unlawful for KSD to do the disconnection. The applicant was then ordered to pay one third of estimated claim of R3 150.15 (Three thousand one hundred and fifty rand fifteen cents only) made by KSD municipality.

All power utilities in South Africa have attempted to address poor revenue income through installation of prepayment meters instead of disconnection. Mpofana Municipality in Howick have installed hard-wired split prepayment meters in the Mpophomeni Township. Eskom installed split meters in Edendale Pietermaritzburg, whilst EThekwini have done the same in Northern part of Durban, but all these initiatives became temporal and customers continued to bypass meters and continued to consume electricity without payment.

The municipal debt alone amounts to R14 billion and South Western Township (Soweto) such as in Tchiawelo and Orlando West, in Johannesburg alone contributed more than R14 billion (Hadebe, 2018). This amounts to almost R30 billion of revenue income deficit. In July 2018, Eskom signed the loan of R33.4 billion with the Development Bank of China in order to complete the construction of Kusile that started in 2008 and to ease Eskom liquidity crisis. This will increase national debt, as government is the Guarantee for the loan. Question 5.7 above was meant to survey the views from respondents within power utility.

In KwaZulu Natal, South Africa, Eskom have installed electricity smart prepayment meters in areas such as Umzinto lower South Coast, Port Shepstone and Esikhawini due to high electricity theft and safety compromise. The review of the installation in Umzinto revealed that the installation of the smart metering had benefits that challenged the illegal connectors. This is because the smart meters have boxes on the pole compared to what is conventionally hard-wired installation in the house. It is unknown whether the technology is sustainable, but the review done on the 22 Dec 2018 revealed that since the commissioning was done in 2015, there has been continuous benefit realization of revenue income.

Kambule, Yessoufou and Nwulu (2018) explained that it is through the Inclined Block Tariff (IBT) that load shedding was not realized earlier than it actually was realized. In this IBT consumers that are consuming more are paying more and those that are consuming less are also charged less. However globally smart prepayment meters have been proven to contribute positively to power utilities' revenue income. It is therefore clear that the impact of non-payment can be minimized. This will be very difficult to implement in the neighboring countries but what is pertinent is that the existence of Power Purchasing Agreements (PPAs) seems to have lost its value due to debt owed by importing countries and non-payment. The following section is testing the value of PPAs between two countries.

When Eastern and Western states were colonizing African countries, the colonized African countries remained under-developed. It is therefore for that reason the African Union (AU) tasked South Africa to champion in the development of other African countries in the form of power-infrastructure development and skills development. Due to the capital-intensive nature of power-infrastructure development, most of the African countries opt to import power. The contract between South African state-owned power utility, Eskom, and buying country, is signed through the participation of Department of Public Enterprise (DPE), Department of International Relations and Co-operation (DIRCO) and National Treasury using US Dollar as the contract currency.

Zimbabwe is one amongst many countries that Eskom supply with power services, construction of power-infrastructure and maintenance where necessary. When Zimbabwe had global economic sanctions, the payment process was amongst the challenges. This led to Eskom to start threatening to cut power supply in order to recover payment. It is believed that South African politicians were among the first people that cautioned Eskom not to cut off power supply to Zimbabwe to avoid opportunistic terrorist attacks to the country and deepening of the country to economic crisis. The limitation on this question was that, estimated to 70% of engineers that participated were younger than 40 years of age. Some of them are even younger than 30 years of age. Therefore, it is likely that they may not understand how diplomatic, bilateral trading agreements and cross-border power purchasing agreements works. It is for that reason it is imperative to mention in this discussion that participants responded in an unconvincing manner. Therefore, the researcher makes the following assumptions.

The first is that participants lacked understanding whether enforcing timeous payments through diplomatic relationship would have positive impact on the utility's revenue income or not. The second is that those participants may have reviewed delays experienced in the development of Grand Inga project 3 infrastructure development and concluded that cross border infrastructure and bilateral trading agreements are incapable of ensuring timeous payments. The third assumption is that participants may have looked in the previous history of South Africa and Libya, where South Africa was unable to recover payment for services rendered, despite good diplomatic relationship between South Africa and

Libya through Former President Jacob Zuma and deceased President Gaddafi respectively. It may further include payment losses between South Africa and all other neighbouring countries. In all these countries, South Africa had good diplomatic relations and bilateral energy trading agreements signed.

Contrary to the above, Zimbabwe owed the DRC power company, SNEL. They cut them off and Zimbabwe paid accordingly. This was the revenue income to DRC. The other example is that South Africa is sourcing water from Lesotho. When South Africa delayed payment, Lesotho threatened to cut of water supply and South Africa paid accordingly. Based on these two examples regardless of the number of participants that responded, it is evident that diplomatic relationships should not compromise power utilities' revenue income.

The discussion related to disconnecting Large Power Users (LPUs) that are defaulting payments, participants (64%) agreed that the infrastructure for defaulting LPUs should be removed to enforce payment. On the other side, there was the strong belief from the participants (82%) that one of the causes for LPUs to bypass power, is because the fine amount paid is very small. This makes the risk to be worth taking as by the time the LPU get caught by the power utility, the business would have made sufficient profit to consider bypassing the meter as worth doing again.

In this study, it was mentioned that there are townships such as SOWETO owing Eskom almost R20 billion. The following discussion relates to the benefits switching off such defaulting townships. The participants (74%) stated that they agree with switching off defaulting townships, with 56% agreeing that diplomatic relationships with neighbouring countries does not fulfil revenue income to South African power utilities. The conclusive approach discussion on this could be that most of the participants believe that switching-off power to defaulting townships such as SOWETO is likely to contribute to the solution.

It is the researcher's further assumption that such response from participants was not cautious of the high number of court cases, where customers took power utilities including Eskom to court regarding power disconnections and where the customers won the cases with costs. The example was when Eskom was threatening to cut off some of eight local municipalities in the North West Province of South Africa for R10.2 billion debt (Writer, 2017).

In townships supplied by Eskom with electricity such as SOWETO, there are businesses and government key services such as Baragwaneth Hospital, local businesses such as tourisms and General dealers that may have detrimental impact when the power supply is cut-off.

Therefore, power supply disconnection could lead to economic stagnation in those townships and there could be contravention of human rights to those living on life-support system. Further to power supply disconnection, sophisticated medical operations in progress could be disturbed leading to the loss of life. The dilemma is that in terms of agreement of power supply, there is power-supply contract document signed between the power utility and customer. The customer is made to provide alternative energy supply mechanisms, as globally, power interruptions due to fault either in the power system or due to maintenance, which are inevitable.

In this discussion, it is imperative to highlight that power utilities in South Africa disconnects residential and business customers for non-payment. The example to this is that when NERSA approves a tariff increase, business sector such as mining, agriculture always complain that they will fail to afford to pay for increased tariff increases. Some of the mines that failed to pay their power accounts had their supply infrastructure removed. Some of the steel companies have raised similar complaints. Steel companies stated that government politics, which is 100% shareholder to power utilities, was failing to provide business sustainability within the global market. Their argument is that for the country to grow the economy, it must increase exports and reduce imports. They stated that among reasons for increased and unaffordable electricity tariffs; include costly imported power from neighbouring countries.

The business sector further argued that South African further failed to repatriate money from countries where it rendered services. In the Sub-Saharan Africa, South Africa has bilateral trading agreements with many countries (DIRCO, 2018) in order to facilitate regional economic growth due to high number of people without access to electricity. There are two revenue income streams that Eskom has in order to remain financial sustainable, firstly is the regulated revenue income stream through Generation, Transmission, Distribution, Energy trading and Export/Import departments and secondly is the unregulated revenue income that is through subsidiaries.

Some of the subsidiaries are providing engineering professional services whilst others are offering construction services in foreign countries such as construction of transmission power lines, training, and construction of hydropower plants, operations and maintenance of power plants in terms of consortiums such as in Uganda (Infrastructure Consortium for Africa, 2016). Eskom have rendered services in various African countries such as Libya, Zimbabwe, Botswana and Zambia. Eskom continues to suffer in the same way that they use to suffer of failing to recover payment. However, these lessons learnt are not shared properly it becomes knowledge of closely involved officials.

Some of these lessons could be the understanding of foreign tax laws. If the country has conducive tax laws for conducting business, it is easier to attract investors. Azemar and Dharmapala (2019) described that foreign tax laws are ways in which developing countries attracts foreign direct investments (FDI)

but foreign tax differs based on bilateral treaties from country to country driven by business structure with that country in terms of Multinational corporations (MNC). As stated earlier, lack of understanding foreign tax laws has resulted in many South African companies losing revenue income. Some of these companies are as follows:

- MTN, which is the telecommunication company conducting business in South Africa also entrenched in Nigeria is in court due to tax related matters, with the Nigerian government claiming them N242 billions and USD $1.3 billion for tax and import duties. MTN believes that Nigerian government is acting outside their jurisdiction.
- Eskom conducted construction business in Zambia but could not repatriate payment of R2M due to foreign tax laws. On claiming, it became another challenge as Zambian government claimed that South Africa did not follow the tax procedures properly and Eskom was supposed to pay back the government R3.5M.
- Eskom conducted operations and maintenance business in Libya when the deceased President Gaddaffi was still the President. Eskom never received payment due to political issues and foreign tax matters.

The challenge of providing service in foreign countries seems to be the challenge in South Africa or the challenge of the developing country to another developing country. Rosatom signed nuclear power plants development Memorandum of Understanding (MOU). Rosatom is the Russian state-owned company that became prominent after South African government awarded the tender for building 9600MW nuclear power plant in Cape Town.

It is the same company that according to News24 (2018), signed 1MW deal with South Africa in July 2018. In 2017, Rosatom signed power-infrastructure development deals with 14 African countries. As China is doing business with many African countries and receive timeous payment, the study believe that Rosatom will also be able to receive timeous payment due. They will not be experiencing what Eskom is experiencing from neighbouring countries. This belief is driven by the fact that Rosatom is conducting business internationally, they have more experienced legal team, including on tax related matters, compared to South African power utilities.

On the engagement of various key stakeholders related to Eskom Integrated Africa strategy, which is the strategy of Eskom to offer engineering, procurement, construction and management (EPCM) includes training in selected African countries. It became evident that this is not only Eskom that is facing this challenge but most of the South African companies do not know what to do when another country is not willing to pay for the services rendered. The reality is that government is unable to generate revenue income in order to sustain power utilities.

The decline in alternative energy costs such as installation of solar panels on roof tops and development of low noise generators may be the solutions. These business solutions exacerbate power utilities revenue income challenges. Some of the municipalities receive significant revenue income from electricity sales other than government equitable share, which is government financial support. In order to maintain this revenue income, innovation such as that mentioned by Ekurhuleni Metropolitan to link water, rates and electricity is necessary. It is the same system encouraged by Msunduzi municipality.

The challenge with this system is its link with the property value and payment of property rates. Another point for this discussion relates to the business sector installation of solar roof top panels. This led to municipal revenue income declines and the risk of relying on low revenue income, generated from residential customers. South African power utilities have challenges in collecting revenue from townships. The vertical alignment of power utilities towards government and the ruling party makes it impossible for power utilities to recover revenue from defaulting neighbouring countries and municipalities. This discussion makes it important to realize that insulated power utilities' autonomy from political interference will improve power utilities' business. In this discussion, the study is cautious that government revenue (2013-2017) cites two risks of electricity exports in energy security.

Firstly, it raises that the discussion of leveraging supply and demand for power utilities' market. In this, it states that the risk of importing countries is that domestic electricity production stagnates. Secondly, the exporting countries end-up relying on electricity export revenue-income as means of compensating domestic revenue losses. Power-utilities in developing countries possess both these risks (as stated by Energy Research Centre (ERC), Council for Scientific Institute Research (CSIR) and International Food Policy Research Institute (IFPRI), 2017, when reviewing government revenue).

In this discussion, it is imperative to state that in all regions the degree of cross-border power purchasing agreements get measured comparatively with the world statistics. In the developing countries such as in Africa, the discussion has been led through the consideration of Kazadi et al. (2016) on the 2012 review; they found that Africa had very low electricity export trading status (3%) with cross border electricity export trading. This comparison was also done with other energy exports such as oil export (52 %) gas export (31%) and coal export (17%). African region has the most fuel reserves compared other regions in the world. In Africa, political instabilities and low economic growth has led to Africa to have the lowest access to electricity (600 million people without electricity) compared to other regions such that Africa requires USD $ 400 billion to meet regional demand of 500Twh by 2030.

Funding such required capital investment through bonds may lead to country's inability to recover from debt, leading to decades of power utilities' losses. Therefore, this discussion acknowledges that there is a lack of adequate infrastructure and capital investment challenges facing power utilities. The focus

point of this discussion is to ensure that this lack of power-infrastructure challenge is met through equities.

It is therefore imperative to lead this discussion through understanding how other power utilities globally deal with challenges faced by South African power utilities. Li and Youngho (2015) was emphatic that in other regions such as European Union (EU), which is the region comprising of developed countries, but it demands 76% of transmission capacity to meet its long-term electricity market (up to 2030 as it is with African horizon). The achievement of timeous payment is through long-term supply and demand agreements, with the contract signed through the Central Bank that will act as the security to assure payments for the services rendered. The agreement is such that there is an agreement of the power demand monthly and annually and cost payment thereto. On a monthly basis, the Central Bank ensures that the power utility receives payment through the fund already reserved. This leads to power utilities from developed countries to have better financial performance compared to power utilities in developing countries. In other words, financial institutions partake in the regional corporation agreements such as OECD and becomes central in financial and contract management between countries.

In answering the research question related to timeous payments, one of the questions asked if townships such as SOWETO that are owing billions of rand can be switched off. In discussing this, the literature review revealed that, the replacement of conductor technology worsens the revenue income. The first rationale is what Olaszi and Ladanyi (2017) concluded on the 15 houses stochastic modelling study using batteries to simulate what battery size can be suitable for each house. One of their findings has been that it is difficult to determine what size as well life span of the battery due to variability of the demand during the day and week. In their findings, they stated that this was the challenge for the life span of the battery and the required battery bank.

The second rationale is that it will increase the complaints and operational expenses when exchanging damaged batteries. South Africa is still battling with the storage of solar energy for industrial and commercial sector supply. Most of consumers of solar supply are strictly dependent on solar radiation availability, even solar robots in major cities, if the power goes off or if it is raining for consecutive number of days, the robots do not work. Reverting back to the question above, if the battery gets exhausted or cells die, the loyal paying consumers will be as if he is a non-paying consumer as there will be no supply.

Hilton, Cruden and Kent (2017) in their study in the UK, describe domestic battery technology that has to be connected to low voltage system as helpful to support both domestic and off load shaving. The load shaving is ability to reduce load from the grid by shifting it to the battery as the energy source. In other words, they did not look at batteries as the energy source viable for baseload supply. Chiacchio et

al., (2018) spoke of the photovoltaic power plants used in Italy for domestic supply in order to reduce energy demand from the grid. The battery technology reduces importation of grid energy thus reducing load.

The understanding of this technology in South Africa is still in its infancy stage but there are many talks related to its usage more particularly for the storage of solar energy. The participants of this study are familiar with the topics but not exposed to the functionality of the technology.

The evolvement of smart prepayment technology or Smart Grids (SG) has faced number of protests in Soweto, as consumers felt that Eskom wanted to control power supply and payment. The Smart Grids meant that the power utility would be able to optimize demand from residential customers and be able to reduce their load from the grid. This is where the advantage of batteries would beneficial as the during the peak demand, some of the township load will be diverted into batteries.

The previous programs or initiatives such as operation Khanyisa had minimum impact, which never solved non-payment problems that Eskom and many South African power utilities are facing in most of the South African townships. It is the assumption from the researcher that these engineers had these perspectives when they responded by saying disagree.

6.2.3 The extent of investment opportunities lost due to costs escalations

There were five questions developed to provide contribution towards answering above- mentioned research question in section 6.2.3. Amongst questions consolidated to answer, the research question was the first question that was aimed at determining the possibility that cost escalations in power-infrastructure capital investment could be as the results of inability to enlist and manage expectation of stakeholders. The second question was aimed at making the discussion regarding the deployment of strategic resources to departments that were deemed as critical stakeholders such as government departments.

Furthermore, the third question leads to the discussion to determine the possibility of containing cost overrun by compacting stakeholders involved in capital-power-infrastructure investments. The fourth question was aimed at determining the possibility of the role played by the trade unions, as it could be reasons leading to cost overrun and schedule delays during protest. The fifth question, led to last discussion, related to the possibility that the stakeholders, both politicians and the business sector, uses short-term employment called EPWP to delay projects thus leading to cost overrun and schedule delays.

In all these questions, participants strongly believed that the cost in power-infrastructure capital investments mostly (87%) escalate due to stakeholders that do not enlist their expectations. This response from participants reflects what the literature review presented. The changes in any

infrastructure development should be discussed during the early stages such as during the feasibility study or during the concept stage. This is the appropriate stage for stakeholders to have better influence and to ensure that their expectations are incorporated with least cost.

The second question (86%) meant that participants believed that the Project Leader should be able to develop and set stakeholders' performance compact in order to contain cost overrun. Thirdly, participants (72%) at least agree that approval delays for the issuance of permits or licences can be minimised.

The discussion related to trade unions provided a response that is the total opposite from what was expected. The timing for sending the questions to the engineers regarding the role played by the trade unions in cost overrun and schedule delay may have been inappropriate. The questions were sent after salary increase strikes mostly by participants (majority of engineers) that resulted in load shedding. This may have made participants to answer this question subjectively, feeling that the question was trembling on their right to protest. In South Africa, it is individuals' constitutional right to have freedom of association and to have peaceful protest with the exception of those in essential services, like power utilities. Power utilities are classified as providing essential services and employees are forbidden from striking but regardless they do. This leads to load shedding and high frequency of power failure.

On the contrary, power-infrastructure development in Eskom and in municipalities faces delay due to protest. What is important to mention in this discussion is to state that although there is a response from participants that EPWP has cost and schedule delay impact, they are not the major contributor. This response is appropriately acceptable.

All the participants in the study believed that when stakeholders are engaged early enough, and their expectations managed properly, the stakeholders can have positive contributions to the project. The changes on the complete design or during construction are costly and tedious. It is even more costly when construction has started, as it leads to delays when effecting changes, seeking governance approval, and waiting for the funds to be uploaded in the Cost Breakdown Structure (CBS).

In the external stakeholders' expectations management, the biggest challenge is the insinuation that was made by some of the participants. They insinuated that the silent expectation from majority of politicians is regardless of how beneficial the capital power-infrastructure investment is to the community. Their expectation is the self-enrichment that the investment will bring. If self-enrichment opportunities are not specified, politicians can even sabotage the very same development that will bring socio-economic benefits.

Contrary to the above, some participants stated that unless there is a disjoint between Ministers and Councillors in terms of service delivery, there would always be opposing interests related to capital infrastructure development. Ministers sitting in parliament are expecting to see benefits of their budget to the people that elected them to be in parliament but councillors are seen as people that are in the opposing forces, if there is nothing that will ensure their personnel enrichment or lifestyle sustainability.

Globally, in the developed countries, the stagnation towards the development of power-infrastructure has been as the results of legal matters such as property ownership. Further to that, delays were mostly due to environmental activist such as in the case of developing wind power-infrastructure, as stakeholders believe that wind turbines kill birds. Other than wind power-infrastructure, nuclear development faces a lot of public protest. Similarly, the environmental protests have been experienced in South Africa regarding the development of nuclear power plant in Cape Town. These are stakeholders.

In Africa, the reaction of stakeholders depends on the developer of power-infrastructure. There are many reasons that has led to delays such as political approach as it is the case for DRC for the development of Grand Inga 3 project. Stakeholders believe that the World Bank has ulterior intentions which are not only to fund power-infrastructure development but also to extract mineral resources. It also differs where Chinese are developing power-infrastructure, as stakeholders' resistance is due to the fact that Chinese are deemed exploitative, paying low wages or at times do not pay at all, do not provide adequate accommodation and do not want the involvement of the trade unions in business dealings. Therefore, stakeholders end up engaging towards resolving such matters.

In the case of South Africa, there are historical issues that has led to delays such as political issues. In KwaZulu Natal, for example, the delays were also happening even when the contractor was appointed. In this, certain IFP leaders influenced their community to reject electrification, as they claimed that lighting at night was going to damage cattle's' eyes. The fear of being killed resulted in those communities remaining not electrified.

South Africa also faced a high number of protests related to basic conditions of employment act by Department of Labour. These conditions work collaboratively with Occupational Health and Safety Act (OHS Act). The failure to apply all these regulatory laws results in workers (stakeholders) supported by their politicians to delays capital power-infrastructure development.

Lastly, on this discussion, South Africa have environmental protection activists that have to be engaged as key stakeholders. In current practice is that power utilities experience at least two years of delay from Department of Environmental Affairs, before getting environmental authorization. The environmental authorization is applied for after the approval of the feasibility or concept. This delay is as the results

of appointment process of environmental consultant, site investigation, the public consultation, report writing and conditional issuance of permit. This is the tedious long process, results in scope and cost changes after the permit has been issued. In the places where the power-infrastructure will be developed not very far or within established community villages, changes are experienced during the two-year process.

For example, in the place where the substation is planned for development, when receiving the permit after two years, it is more common to find houses already built in the planned area. This means that the new site has to be investigated, ring-fenced and follow the re-application process that may take another two years start again. In shortening the above process, the officials from power utilities will get alternating deployment, trained and given access by the Department of Environmental Affairs and working to ensure that requests from power utilities get processed quickly.

6.2.4 The systemic model formulated to evaluate the long-term power-infrastructure investment in South Africa

There were six questions developed to provide contribution towards answering above-mentioned research question in section 6.2.4. Amongst questions consolidated to answer the research question, was ROI as the first question. The ROI was aimed at determining the possibility of making investment decision on false aspirations. The second was question related to IRR that was also aimed at making discussion regarding possibility of making investment decision on false aspirations. The third was the NPV with the similar aim. Further to that, the fourth question was to lead the discussion regarding investment viability of rural or urban electrification. The discussion is followed by what is most likely be regarded investment-returns possibilities, linking the internet to electricity. The last discussion, which is the sixth will be on challenging loan repayment premiums paid by private and public institutions to foreign investors.

At least more than 70% of the participants agree that ROI, IRR and NPV is not realized in most of the power-infrastructure capital investments. These above financial models are the key in making investment decisions. It is further known that for any investment decision to be approved, requires maximization of investment returns and community benefits, reduction of risks, reduction of environmental impact and emphasis on the ease of construction.

The maximisation of investment returns in this would be through the calculation of NPVs. It would be the income cash flow projections starting from the year one until the last year of financial income. There is further discussion related to these financial returns starting form section 6.4.1, particularly on how these financial models are derived. In the case of reducing risks, the motivation during the feasibility study is made as such that the investor realizes financial security. Further to that, it is a known fact that

once an investment contract is signed with the primary financial lender, any modification or variations for additional money has to be approved by the same primary financial lender.

In other words, when South Africa is funding the power-infrastructure development project through the loan from World Bank, once the investment contract is signed with the primary financial lender, further loans with another country has to be approved by the same primary financial lender. Unfortunately, this is regardless of whether the initial forecasted investment returns will be realized or not.

More than 76% of the participants at least agreed that there is a need for new financial models that will be used in order to realise benefits. This is regardless of some of the initiatives that power utilities have to link internet with electricity payment. This assumption will neither improve nor sustain power utilities' revenue income due to wireless access to internet services. Telecommunication companies such as Vodacom, MTN, Telkom, and Cell C and so forth have reduced cost of data through mobile phone packages.

In this discussion, it is worth mentioning that some of the investments are not profit driven such as electrification of rural villages. Therefore, the contract for electrification should had been structured as such that the power utilities become the construction contractor and power system controller but matters such as maintenance of assets and capacity expansion be localised to some of the private companies. In this model, it would mean that power utilities would have equity stakes and act as the shareholder's representative.

Summarily, there is a strongly agreement and agreement that the current systemic model that is used to evaluate, measure and control performance of capital power-infrastructure investment need to be remodelled with the high focus on making sure that the current financial evaluation model that is used be high priority.

All power utilities are vertically integrated and managed by government as the shareholder. The long-term shareholder's strategy to transform these power utilities from liquidity status to equities are not yet commonly known. For example, the most common cause of cost overrun realized was the type of the contract used to deliver the capital power-infrastructure. Government should capacitate these power utilities such that they could start making profit through manufacturing of goods and selling to each other. For example, if Eskom as the main power utility, it could be able to make transformers or other related switchgears and sell it to municipalities, or to other state-owned Companies such as Transnet, South African National Defence Force and other private companies. There are many engineers, technicians and electricians at Eskom that could make that possible. This is the unregulated revenue stream that it outside NERSA Approval.

The other approach towards realization the reduction of risk in the unregulated revenue income stream is to be in partnership in the form of PPP or Joint Venture with other international service providers such as ARUB, ABB, Siemens, General Electric, and Alstom. Municipalities can be able to assist in the provision of products such as cables and conductors. These power-engineering products could be exported to grow the economy. This will create jobs, stimulate economic growth and reduce pressure to government's intensive capital budget.

In the development of Medupi, Kusile and Ingula as Mega-Infrastructure investments, the South African Supply Chain Management policy such as BEE was considered and applied through SD&L policy. The implementation had poor architect towards the sustainable benefits of black people in terms of skills development and monetary gains. The majority of local black companies that worked in those projects liquidated during construction. Some of these companies had high CIDB grading in South Africa but were not successful in the tender business. Some of the foreign companies that were successful were doing the job for the first time and were short of resources. In this situation, it raises questions regarding the evaluation of tenders. It starts to question if Supply Chain Management policy was applied equally to all those that tendered.

There are more systemic models discussed, such as turnkey solutions instead of multiple packaging. The example of this is that there has to be one primary contractor for power station construction development. All other required services such as boiler, civil, and water infrastructure installation had to be sub-contracted to the main contractor. In the case of transmission and distribution, it would mean that the construction contractor will be the one appointing the consultant and all other power-infrastructure development related agents including environmentalists. This model would shift the risk from the power utility towards the contractor and contain power-infrastructure development costs. In other words, the risk related to cost increases due to design changes, the construction complexity and penalties including environmental non-compliance issues will be borne by the contractor.

The knowledge management was strongly echoed by various participants. One of the participants even made an example regarding research by international consultants, that they have the strongly research engines and be able to respond back to the client immediately. This model can be used including in competing for the installation of solar panels. Further to this, the model towards selection of what is deemed as mega-infrastructure projects requires modelling.

The last discussion is related to financing South African power utilities. The financial security analysis including models used by western countries, ranked African countries as high financial risk. On contrary, this has created western countries to invest their financial stock reserves with high interest rates in to African countries as their financial market. This requires stoppage if not minimization.

Minimization will happen into two forms; the first being capacitation of internal organs of state and lastly the development of States' bank such as BRICS.

In some of the developed countries, there are models already developed such as the percentage rebate after paying for electricity. In those developed countries, paying for electricity means standing a chance of winning the lotto. The percentage amount of electricity payment is reserved or re-routed towards playing lotto of behalf of electricity account. This makes the electricity account owner to stand a chance of becoming the multi-millionaire.

Secondly, business tax and Personal Income Tax (PIT) is as such that business comply with electricity payment to avoid litigations. It has been mentioned above that Africa has become the financial market for developed countries. This is because of the consistent debt payment, which has reduced financial risks from foreign investors. The challenge is that the payment of premium is still high with every investment allocation compared to developed countries. Contrary to that, the tax collection is low with the exception of South Africa. AU gave the tax exemption to most of the Multi-National Companies (MNC), which amounted to USD $300 billion in the last financial year. Africa requires USD $400 billion in order to meet capital-power-infrastructure investments demand in 2030. In order for Africa to fund its own infrastructure development, the continent need to remodel the tax exemption system currently benefitting MNC. The majority of these MNCs are not investing further in the continent of Africa but are investing in foreign countries and offshores. MNC tax exemption requires modelling in order to assist in the evaluation and long-term investment in power-infrastructure (up to 2030) instead of raising PIT.

South Africa, as mandated by AU to champion the development of infrastructure in Africa delegated Eskom to lead in power-infrastructure development. South African government's credit ranking (the 100% shareholder of Eskom) is that of a high investment risk country meaning high interest rates of premiums for repayments. South Africa and Eskom is requiring alternative financial lenders that will disregard existing credit rating agencies, which are highly politicised in order to raise debt on low interest rates. These financial lenders could include Banks proposed to be established through BRICS. These financial lenders should have strong balance sheet for development of infrastructure in Africa as it is the case with Development Bank of Southern Africa (DBSA) and African Development Bank (ADB) other than from World Bank. It is through financial resources that Eskom will be able to compete with foreign resourceful power utilities such as Rosatom (Russia), and Westinghouse (USA) in the development of power-infrastructure in Africa.

This further requires the establishment of better financial models other than ROI, IRR and NPV. As stated earlier, these models are not sensitive to total complexity factor, foreign tax laws and the risk of

financial repatriation. Further to that, systems thinking is required to determine what are other challenges affecting capital-power-infrastructure investment.

6.2.5 The impact of systems thinking in procurement of long leads goods and contracting of foreign skills

There were five questions developed to provide contribution towards answering above mentioned research question in section 6.2.5. Amongst questions consolidated to answer the research question, was to determine how participants believe the delays of acquiring foreign purchased goods have on cost incurred whilst developing power-infrastructure. The other question was aimed at raising discussion regarding what impact could the freight sector have in delivering foreign or long leads goods.

There is also another question aimed at creating the discussion towards the utilization of foreign companies and their contribution towards skills development. Moreover, the remaining two questions aimed at creating discussion in this chapter regarding possible manipulation of the contracts signed for the development of power-infrastructure and fifthly which is the last question raises the discussion regarding IP for the development of power-infrastructure.

In all the questions related to answering above questions, the response was good enough considering that during the survey, only engineers in leadership positions had attended Middle Management Program (MMP) with Da Vinci institute, which included systems thinking. Most of the engineers doing designs, processing environmental studies, dealing with costing, and plant life cycle had not been trained in systems thinking.

The worst is that these days, power demand engineers cannot forecast and be able to tell suppliers how many transformers, poles, quantities of a certain conductor types they will need in the next five years. This is the according to short-term, medium-term and long-term expenditure framework in order to prepare suppliers of the possible future demand. The current reality is that when there is an increased demand for transformers or poles, it becomes unavailable as there was insufficient plantation done.

Resorting to foreign goods does not assist power utilities in realizing their core mandate of growing the economy. Participants at least agree that foreign goods and service are the major contributor to South Africa's power utilities' capital challenges. In the first point of discussion is that participants (76.14%) believed that foreign countries that have to play supervisory roles instead of doing actual work, where skills required is due. In this strategic arrangement it means Intellectual Property (IP), including details of commissioning procedures must remain in RSA when the contractor or supplier that was conducting work has completed.

The second point of discussion is that participants (62%) agreed that delays experienced waiting for imported goods becomes costly Interest During Construction (IDC) and delay damages. These costs are borne by the buyer, the power utility, in the form of cost variations, the delay damages and schedule delays. In other words, these costs become investment opportunity cost. Further to this is the delay as the results of the freight strike. On this, participants (at least 64%) believe that it does create power-infrastructure commodity shortages such as steel, copper, and wood poles. Further to that, participants (at least 65%) believe that the existing regulatory laws such as SD&L, and OEM, are amongst the causes for delays leading to power-infrastructure development challenges.

This is because these regulatory laws are not part of the proper plan towards ensuring that delays are averted. Lastly, systems thinking led to the determination that there is manipulation of the contract by either stakeholders or contractor and local skills development by foreign companies. This is further discussed in the systems thinking model appearing in Appendix B.6. Participants in these questions responded by at least agreeing and strongly agreeing by 55% and 75% respectively. In terms of quantitative data analysis, the majority of participants believe that there is manipulation of contracts for power-infrastructure development by foreign companies (including local companies) and there is further failure of skills development.

All participants resulted in the overall acceptance that there was poor planning in the total execution of mega power-infrastructure such as Medupi, Kusile and Ingula. The reasons for schedule and cost overrun varies in all these projects but the denominator is improper due diligence towards the realization of initial forecasted financial returns. Secondly, lack of doing proper environmental studies were among some of the reasons that lead to cost overrun.

All the historical battlefields are documented either in the local museums or through information available from the library. Therefore, the cost overrun together with schedule delays experienced in Medupi, Kusile and Ingula should have been avoided should the environmental studies due diligence was conducted.

Foreign stakeholders' impact toward cost overrun and schedule delays requires further discussion. In 2004, when South Africa realized that it was failing to secure IPPs and reviewing the alternative plan of building coal fired power stations was supposed to send personnel to developed countries that will either be in investment committees (governance) or provide adequate assistance towards the approval of costs variations and contract modification. The participant stated in Kusile, foreign companies stated that they have designs, implying that the design skills for a similar power station such as Kusile existed and constructed somewhere.

Contrary to that, participants stated that most of these foreign countries never had experience of what they were doing, as they were doing it for the first time. The contract signed in foreign currency when

there is a time extension modification mostly driven by insufficient experience in doing the same work. This means that the adjudicating for South African companies was inclusive of the CIDB grading whilst foreign companies were evaluated differently. Therefore, the comparison was not on par as companies were evaluated differently.

Transfer of skills including of actual tendering should have been ensured by the South African government that local companies receive proper skilled development into how to tender in those construction contracts. In support of the response, the participants stated that most of the South African companies liquidated. The realization of initial strategic intent, and SD&L planned were unsuccessful. The foreign companies managed to extradite funds outside of South Africa.

There are also discussions related to occupational safety procedures in South Africa, the inability to engage stakeholders regarding expectations of proper accommodations (OHS Act), and safety compliance requirements resulting in cost overrun that could had been avoided.

Contracting discussion relates to the open-ended contract signed between the contractors and power utility. There are allegations that the contract was influenced by corrupt dealings, however, what is strange in this contract was its relative liquidity towards foreign exchange rate (US Dollar to the Rand). The rand weakened, making modifications and purchase of foreign goods expensive. This was as the results of the same open-ended contract.

Therefore, the application of systems thinking will fully explore how the paradigm will shift to the direction that will benefit South African power utilities. In this belief, Lane et al (2016) has cautioned against possible eruption of socio-political hindrances, as the constitution of social engineering requires proper observation. World Bank and IMF can be deemed as capitalizing developing countries if observations of the protocols are compromised (Stanley, 2013). Therefore, systems thinking will provide the holistic view and lead towards addressing power-infrastructure challenges.

In the holistic application of systems thinking discussion below, the quantitative, qualitative research data and literature reviews forms the model.

6.3 DISCUSSION ON THE REGRESSION DATA ANALYSIS

In Chapter 5 Section 5.2.2.1, the presentation of data analysis revealed that there is a consistent relationship between dependent and independent variables. In all the pairs of questions, it is evident that respondents provided logical interpretation as the relationship between variables were within acceptable limits. It is therefore evident that this data is acceptable.

6.4 THE APPLICATION OF SYSTEMS THINKING IN REVIEWING POWER-INFRASTRUCTURE CAPITAL INVESTMENT

In Chapter 2, the theoretical framework for systems thinking was presented. Summarily, its definition is that it is a discipline of seeing underlying complexity of a particular world situation by analyzing deeper patterns in relative to certain underlying events. Systems thinking helps in approaching complex problems, challenges or opportunities holistically.

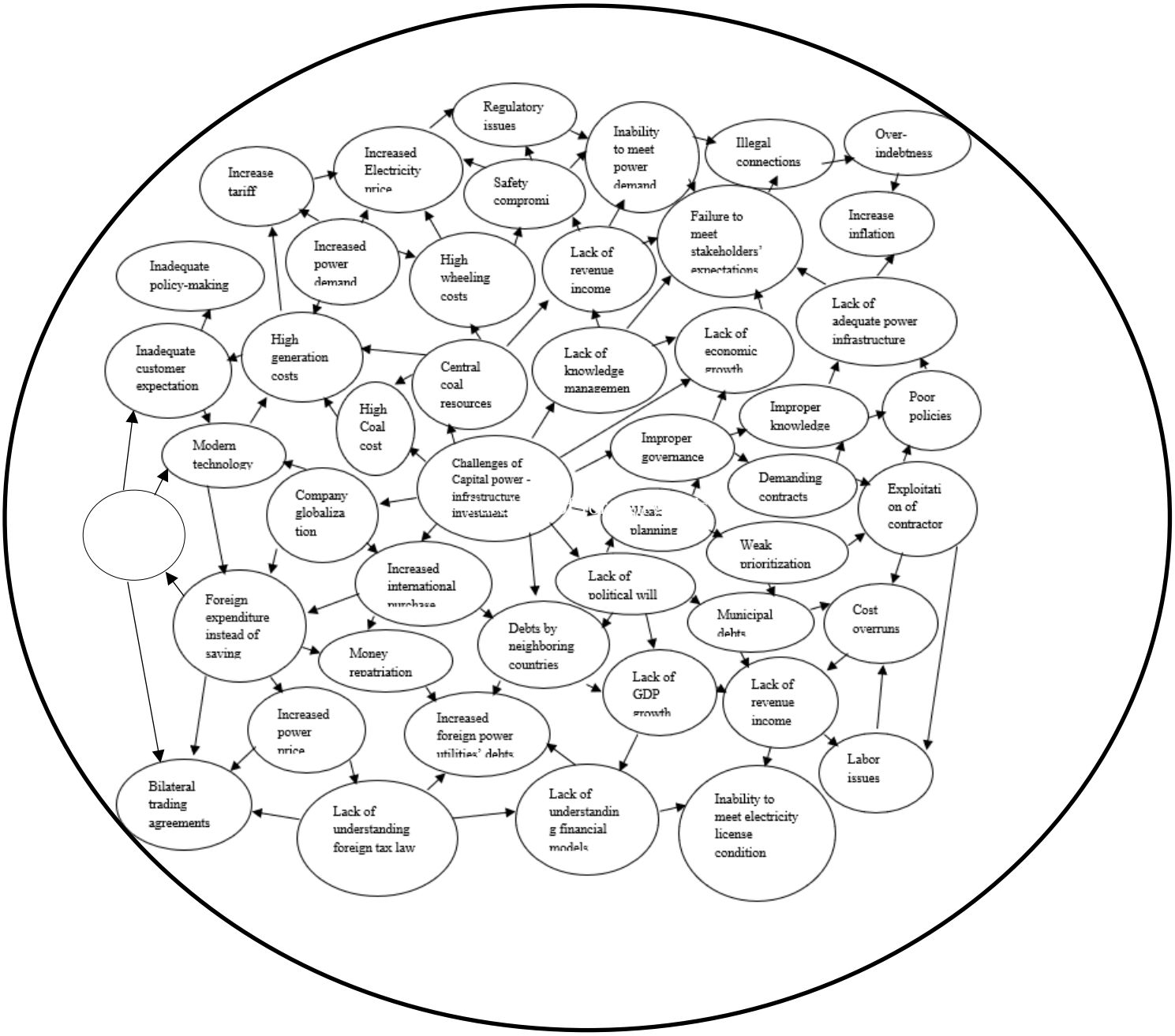
The benefits of using systems thinking include the creation of another perspective to the complex situation, proper identification of all root causes and drivers of the complex situation as presented by Senge (1990). This assists in the creation of the structure for short and long-term planning. The presentation of perspectives is in the form of boundaries with arrows illustrating how it is influencing the other nearby environments.

The determination of drivers is through the number of arrows coming to the boundary or away from the boundary. The descending orderly arrangement can be such that the most impactful boundary will receive proper prioritization. The perspectives developed through-out this study are as presented in Diagram 6.1 below.

In the following diagram 6.1, there are texts written inside the circles called affinity diagrams. Arrows present the illustration of interrelationships described within affinity diagrams. The sequence of how affinity diagrams relate has been through the analysis of both literature review, quantitative and qualitative data gathering. These analyses determined which activities have arrows pointing towards them or away from them.

The determination of the arrow direction has the element of subjectivity, as it is based on the literature reviewed, how participants responded when interviewed quantitatively and qualitatively, and it depends on the organizational knowledge. The activity where the arrow departs is regarded as influencing the activity where the arrow is pointing. The following Figure 6.1 depicts systems thinking model, this is also depicted in appendix B.6, page 256 in a landscape format.

Figure 6.10: The systems thinking reviewing challenges in capital power-infrastructure investment



The above Figure 6.1 **(Preferably to be read from Appendix B.6 available on page 256 due to poor quality on this page)** presents systems thinking based on the literature review, both qualitative and quantitative data collected from the research and tacit knowledge. Discussion of Diagram 6.1 will be in conjunction with other diagrams and/or tables. There are 10 primary challenges that this study discovered. These primary challenges are the root causes of all other challenges in the power utility, but they are leading to secondary challenges and extend to tertiary challenges. In reading diagram 6.1, in the centre there is affinity diagram stating "Challenges of capital power-infrastructure investment" with arrows pointing away to other activities. When analyzing the causality, the sequence is to start from the

centre towards outside. Referring in diagram 6.1, the starting point is from the centre, the sequence thereafter whether it is clockwise or anti-clockwise is personal choice. It has no bearing to the actual outcome of the research. In this study, the central coal resources were the starting point and proceeded in an anti-clockwise format. The reason for this is that there are known facts and researched facts. For instance, it is the publicized fact that coal mining is centrally in Mpumalanga Province. It is further a public fact that it is a high cost commodity. In an anti-clockwise discussion approach on Diagram 6.1, issues such as weak planning and improper governance will be discussed towards the end.

The first primary challenge discovered is centralized availability of coal resources in Mpumalanga Province. There are no coal mines in Eastern Cape, Free State Province, Northern Cape and Western Cape with sufficient coal stockpiles or resources to convince investors for the development of power station in those provinces. This means that the power supply to provinces where there are no power stations has to be through the construction of power line infrastructure. This will require capital investment mostly from developed countries or foreign investors or lenders that will charge the interest based on South Africa's current credit rating. Currently the achievement of power wheeling is through long distances traversed by power lines from Mpumalanga to various provinces.

For long distance power wheeling, Eskom has to get more revenue income in order to be able to sustain and to withstand operational costs increasing at 36% per annum. The ever-increasing power demand in remote areas requires capacity expansion investment substantiated through both OPEX and CAPEX investment planning requirements. The challenge that power utilities are facing include high tariff regulation that is below inflation. The Eskom Group Chief Executive Officer, on the 05 February 2019, stated that the complexity in making Eskom profitable is that tariff increases are below inflation rates as heavily regulated by NERSA.

It is the business development strategy that when there is an increase in demand, it means the supplier has to expand the supply capacity to withstand the demand. This means additional capital investment and acquisition of additional resources. This is not different for power utilities, including Eskom. The increase in demand means that there has to be further negotiation with NERSA for tariff increases. Negotiations with NERSA requires the process of public hearings in the entire country where power utilities engage the community stating reasons why there has to be tariff increases. In most of these hearings, the residential and the business sector objects to the tariff increase citing various reasons such as maladministration, in adequate revenue collection, corruption and high salaries for power utilities' executives. Customers do not state their illegal power connections, meter tempering, and their electricity non-payment as reasons leading to power utilities' revenue income challenges.

The second primary challenge is the increase in coal cost that is above industry norm for power generational purpose. In every business when there is an increase in demand, the supplier expands

capacity in order to withstand the demand. The unregulated high coal costs lead to high power generational costs. The vicious circle is that there is a continuous increase in power demand meaning continuous power-infrastructure development demand. This means continuous investment requirement and the backlog for maintenance and operational costs (refer to Chapter 3, Figure 3.10 and Figure 3.11)

Electricity tariff increase creates expectations from customers that there will be an increased reliability and security of supply. This is more in the business sector, as they demand better quality of power supply service with minimum power interruptions, minimum power surges without causing damage to their domestic or industrial equipment. These customers' expectations and pressure compromises the development of adequate policies. Department of Energy developed the policy for infills (which is the process of connecting new customers within an area with connected customers) charges for power-infrastructure upgrades borne by the power utility even though it leads to the connection of new customers. This is because NERSA's expectation is that the power utility should have power-infrastructure with adequate capacity to withstand the demand due to previous tariff approvals.

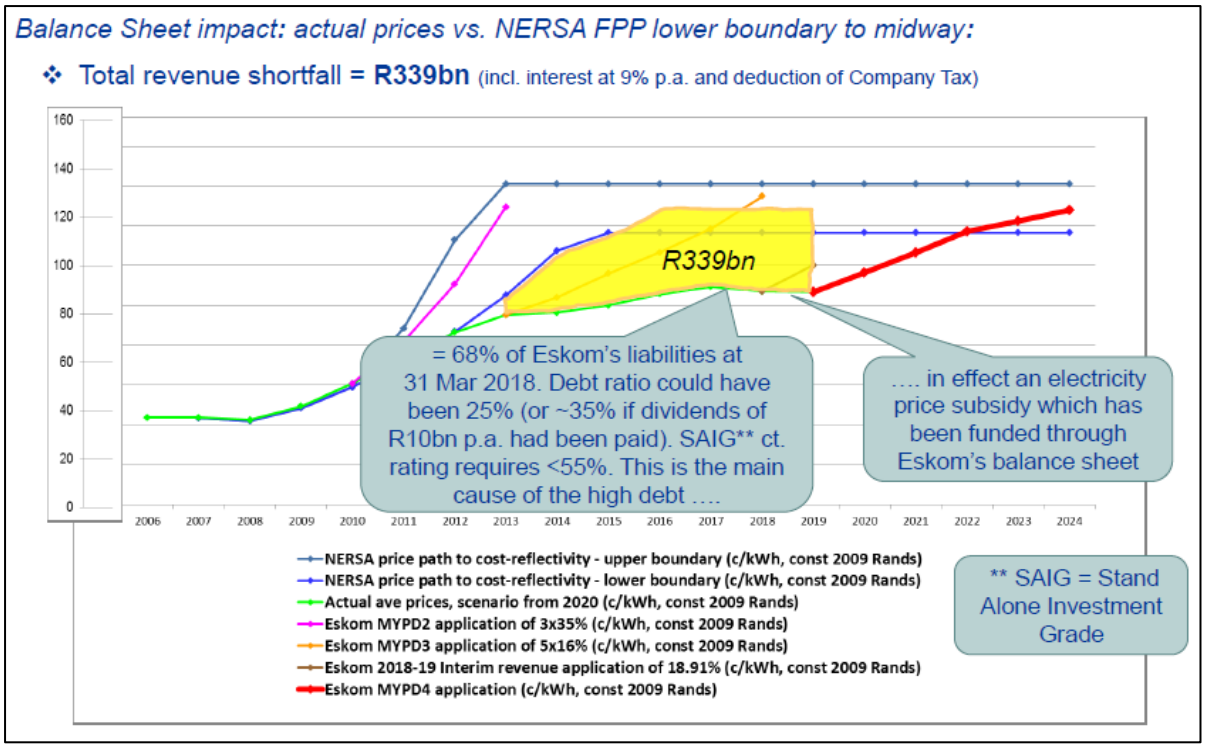
Figure 6.2 presents how the shortfall of tariff increase approval had affected the power utility revenue income. Tariff increase approval has always been unable to address the backlog of power-infrastructure requirement but sufficient to afloat the power utility from liquidity status by pricing minimum. The price is sufficient to afford generation of electricity again at an unregulated high cost and sell it at a high-regulated low prize. The literature presented the tariff increases where Eskom apply using MYPD process to NERSA and got tariff approval below inflation.

In all tariff increase applications, technical, operational and capital performance are among determinants used for Future Price Path (FPP). This include cross subsidization between business sector and residential customers (review Section 3.7, Figure 3.9) which always becomes the contentious issue. This influences generation of low revenue income making it unprofitable. Referring from diagram 6.1 above, subsidizing led to cheap electricity price to residential customers. There have been an additional 1.9 million more customers since the beginning of MYPD2 in 2009 and additional 36000km of power lines built due to market demand in areas that are distanced from a power generation source.

The analysis of what has led Eskom into financial liquidity has attracted stakeholders such as World Bank, Department of Energy's Integrated Resource Plan (IRP), Business Unit of South Africa (BUSA) and Energy Intensive User Group (EIUG) to develop interest in understanding why Eskom and all power utilities are facing a liquidity crisis. The literature revealed that the approval shortfall of tariff increases by NERSA were detrimental and leading to revenue income shortfall of R339 billion. World Bank, who is the investor, believed that the cost reflective Future Price Path (FPP) should be at R1.35c/kwh not the current R0.80c/kwh. However, BUSA believed the cost reflective charge should be

R1.08c/kwh and EIUG stating nothing more than R1.18c/kwh supported by IRP. The following Figure 6.2 depicts the revenue income shortfall as the results of NERSA approval since 2009.

Figure 6.2: Indicating revenue income shortfall amounting to R339bn



Source: Joubert. 2019

Figure 6.2 illustrates the R339 billion revenue income shortfall contributed by the fact that NERSA has approved tariffs below inflation costs on the Future Price Path (FPP). The graph has two cost reflective boundaries named upper cost-reflective boundary (grey color on top) and lower cost-reflective boundary (blue) of tariff increases. The green line indicating that Eskom has been receiving lower than the cost reflective boundary driven that is cognizant of inflation demonstrates the NERSA approvals. The analysis revealed that Eskom will continue subsidizing consumers until the end of MYPD4 and will incur the revenue income shortfall of R107 billion from the year 2019 to the year 2024. This will to the total revenue income shortfall of almost R450 billion from 2013 to 2024. The World Bank acknowledged that Eskom cost is very low comparatively to other power utilities in Sub Saharan Africa (SSA).

Referring back to Figure 6.1 above, Eskom has to correct the current liquidity financial crisis by increasing electricity prices using the red line trajectories until 2024. Figure 6.1 above does not include alleged corruption and maladministration but factually presents costs related to fuel, technical, capital and operational performance. The residential sector still believe that they are subsidizing business sector whilst according to Figure 3.9, the business sector is subsidizing residential sector. In the tariff increase

public hearings, both sectors believe that they are subsidizing each other, and this leads to poor attitude towards electricity payment. There is no evidence that public safety could influence electricity non-payment more particularly because the business sector has to comply with OHS Act requirements.

The composition of South African power utilities is vertical integrated. Government has to have strong balance sheet in order to withstand heavy power-infrastructural budget requirements for maintenance and capacity upgrade. The discussions of unbundling South African power utilities, as they are vertical integrated power and unable to service its debt, have been international proven to relieve government from funding constraints and improves power utilities' credit rating through private investor participation.

The third causality is the globalization of power utilities in developing economies whilst still facing revenue income-deficit challenges. The utilization of global recognized business consultants such as Deloitte, and KPMG, nurtured developing power utilities to compete with global developed power utilities. The global engineering safety and environmental policies published by research companies have influenced companies such as ABB, and Siemens to continue manufacturing new engineering products. However, investing in global technology and the use of international companies have led to the over-expenditure instead of growing revenue income in line with the technology.

Intensive capital investment in global technology whilst there was the power utilities' revenue income deficit was an inappropriate investment. This meant spending more time striving towards making sure that they become among the best top power utilities in the world but that did not translate into revenue income strategies but highly focused in delivering the world standard customer service National Regulation Standards number 47 (NRS047) and (NRS048) policies. The globalization has led most of the power utilities to assume that this is what will motivate customers into paying for the service. Therefore, some of the policies are relevant but currently inappropriate in addressing in addressing revenue income deficit.

Globally customers are not paying for utilities bill in the same way as they would pay for internet and cellphones bill service. The distribution of electricity supply connection is hard-wired compared to the internet where the junction box that is enclosed in a different distant location. The bypass of electricity meter is inevitable as long as there is electricity coming with the live hard wire.

The suggestion by Carter-Brown (2017), on the PowerGen conference held in Sandton, July 2017 to link electricity payment to internet is discriminatory against the middle-income class and not feasible due to continuous development of mobile telecommunication routers. Secondly, it links state-owned public entities with private companies whilst public entities are politically interfered. Another reason is that it compromises the free trading competitive system in South Africa where there is a concern of the

expensive data requiring reduction. Linking expensive electricity together with internet will compromise free trading requirements, it will associate private telecommunication business with politicians, and it will bundle data to expenses of electricity.

It is for that reason in areas known for non-payment such as in Umzinto in KwaZulu Natal South Coast, Esikhawini township, North Coast of Kwa-Zulu, and Alexander in Johannesburg are having normalization investments. This is the public safety investment initiatives that also reduces revenue income deficit. Power capacity-growth rate in South Africa is below economic demand growth rate. The reality is that it is becoming worse as Figure 3.8 illustrates that there is decline in the capital power-infrastructure investment. The challenge related to non-payment of power utilities is happening when the demand for power-infrastructure is continuously growing in the country. The inability to meet power demand leads to illegal connections and further lack of revenue income.

This revenue lose initiative are capitalized requiring to be motivated through the RCA process. Why capitalization of these costs, if they are not what the customer wanted? The revenue income deficit due to meter tempering or illegal connections to transformers or power lines compromises customers' safety. In Umzinto alone, there are undisclosed number people including innocent children electrocuted, mourned for and buried but people proceeded utilizing exactly the same illegal connected infrastructure. This cannot define the culture of non-payment as Umzinto community later demanded safe electricity as they realized that free electricity was the issue of life and death.

The fourth finding is the effect of international purchases including structuring of bilateral trading agreements. Systems thinking discovered that bilateral trading agreement should not compromise cross-border Power Purchasing Agreements (PPA). The increase in the domestic demand above generational capacity leads to an increase in international power purchases, which means exporting from South Africa to neighboring countries for purpose of generating revenue income.

The signage of long-term power purchasing agreement for cross border power-infrastructure requirements comes with contingent liabilities such that even when dropping the load, the country will continue paying as if the demand is still consistent as initially anticipated. This is because when the investor invests in a certain country, the investor borrows money from the certain bank, based on the power purchasing agreement, the calculation of the breakeven point and the payback period that drives the investment decision. When the client, which is now another country, drops the load, the investment agreement must not affect the initial forecasted break-even point and payback period. The inability to repatriate money from foreign countries when Eskom trades in various neighbouring countries has been experienced by MTN in Nigeria recently, due to foreign tax laws.

There have been many models tried for improving international trading relations but some of the tried models included using the international operating bank that will be neutral for both parties, with the international operating footprint to act as the contract holder. The bank acting as the contract holder ensures processing payment after inspection, verification and approval of every hold-point. This is because most of the countries such as Sudan, Libya, Nigeria, Botswana, and Zimbabwe that have faced political instabilities lost forex accounts. Therefore, some other countries that were providing services to them with the contract signed in foreign currency such as dollars could not retrieve their payment when global economic sanctions were imposed. Learning from China is that it is able to recover its payment regardless of global economic sanction challenges. Independent Private Bank is the bank that become the guarantee between mostly two power utilities that are entering into contractual agreement.

This arrangement of using an Independent Private Bank is the same as having the insurance company, acting as the guarantor when entering into international contractual agreement. It is the body that will ensure payment to the other party in line with contractual agreements. However, according to detail analysis entering in such contractual agreement using the insurance company may be a higher risk as some insurance companies may have limited knowledge of international laws, foreign exchange rates and repatriation policies. The foreign policies differ according to countries, which means that any guarantor has to have the contract well crafted.

The demand for power-infrastructure from state-owned company, Eskom, is such that the state must act as the guarantor when the power utility is borrowing money from other countries. The poor credit rating for guarantor and the poor credit rating for the borrower make the repayment and interest rates high for the power utility. NERSA requires that the power utility substantiate both CAPEX and OPEX when negotiating for tariff increase, which forms part of the regulated revenue income stream.

South African power utilities can render services in foreign countries, but the limitations are the ability to repatriate payment. The reasons for the delays in the establishment of the South African state bank just like what World Bank and China Bank for Construction and Development based in Sandton, Johannesburg, were beyond this study. South African state bank could enable borrowing money and withhold money at an exchange fee. That will not only assist power utilities, but all South African power utility companies trading in foreign countries.

In many developing economies, particularly in Africa, there has been a loss of revenue income estimated to more than USD $300 billion due to tax exemption in order to attract them to invest in Africa. These companies have full understanding of financial models and tax implications as they take their profit and invest offshore. Lack of political will in addressing tax implications is among the causes leading to revenue income challenges crippling state-owned power utilities. African countries are known for collecting on average less tax than other countries. South African tax is the highest on the continent of

Africa and even higher than most of the developing countries such as Canada, and UK, yet countries such Saudi Arabia are paying less tax but are prosperous countries.

The fifth primary challenge is debt from neighbouring countries. The relationship of South Africa with the neighbouring countries and the strength of corporation agreement is the provision of services for payment. The fact that during apartheid, some of the South African democratic leaders were living in the nearby countries, developed comradeship that manifested itself in the form of tolerating non-payment. This compromised the strength of bilateral energy trading agreements and corporation agreements signed by African leaders in the SADC summit. In the world, there are various corporation agreements that are existing such as OPEC, and OEDC. The reason why these corporations become successful is the enforcement of the contractual agreement.

South Africa is in the SADC region with countries such as Zimbabwe, Lesotho, Mozambique, Swaziland, Botswana, and Namibia. There are bilateral energy trading agreements with these countries. These bilateral trading agreements are explicitly for business transactions for the provision of services for monetary exchange such as water with Lesotho and electricity with Mozambique using Cahora Bassa Direct Current power line. Failure to pay for services result in the termination of the supply services. There are many of such instances between countries.

In the case of South Africa, there are various instances where South Africa failed to implement corporation agreements. For instance, Zimbabwe owed South Africa for electricity supply. Number of reminders and negotiations went unsuccessful. Secondly, South Africa provided maintenance services in Libya but failed to repatriate the payment. Referring back to diagram 6.1, foreign debt compromises the growth of GDP due to lack of revenue income. Some may argue that this is due to lack of understanding foreign risks and foreign tax laws, as South Africa recently experienced a similar case with Nigeria.

The sixth finding was the lack of political will in addressing power utilities' revenue income challenges. In most power utilities in South Africa, political interference is only for the purpose of being voted into government, which is a dominant challenge, as politicians has no passion for public enterprise sustainability. In most of the power-infrastructure developments, delays were as the results of avoidable protests, misinterpreting existing labour laws and rights to protest by contract workers. Initially some of the protesters were unaware of the truth that the employment was the Expanded Public Work Program (EPWP) designed to give temporary employment. This resulted in protests during contract employment, as some were demanding permanent employment benefits. The lack of political will included inability to intervene when foreign suppliers were abusing Supplier Development and Localization (SD&L) policy.

The development of SD&L policy was to ensure that domestic contractors benefit in most of the tenders nationally. Some of the foreign companies offered local companies sub-contracting opportunities as local supply chain management opportunities but did not act as the supervisor to them to ensure skills transfer such as advising local companies how to price.

Therefore, most of the South African companies ended up liquidating and running of out of capital and leading to cost overrun. Those foreign companies benefited in what has been started by the local contractor, claimed standing time and charge Eskom for rework on the previous contractor's work even if what was left was re-usable.

Lack of political will in this instance would have intervened to ensure that there are proper skills transfer of knowledge from beginning to the end. In many instances, lack of political will lead to proper execution of the political mandate. Among many reasons, why there is a lack of political will is not that there is a lack of political ambition, but it is because there is incompetency and lack of research to understand what needs to be done in order to ensure skills transfer, ensure small enterprise development and to transform political economy.

This become the vicious circle of foreign companies that are signing deals in South Africa and reach an agreement of how to settle debt should South Africa fails to pay. The delay for instance in DRC for the construction of Grand Inga Project is the fact that the proposals related to how the payment will be when the government fails to pay is through the extrapolation of mineral resources, which is believed that it led to political leadership change.

This means that it is most likely that the new government will sign the Grand Inga 3 project. The finding in the literature review is that when foreign investors invest in certain country, it is their utmost belief that they want to be in control including on the governance and project management activities, as they belief that politicians are one of the causes leading to delays. In the literature review in Chapter 3, it became evident that foreign investors also want to dictate which contractor will have to deliver the work. This contradiction instigated foreign suppliers to lead South African companies to failure. The failure again of the South African companies would have led to their contract employees retrenched, causing another delay and cost overrun. The lack of political will leads to municipal poor revenue income by political alignments, which are not only limited to the current ruling party. Even in areas such as Johannesburg Metro, Nelson Mandela Metro and Cape Town Metro, where Democratic Alliance (DA) is governing, municipalities are facing the challenge of revenue income shortfall due to non-payment. Politicians are not emphatic on the need to pay for electricity and water services, even if the service is supplied to neighbouring countries where there is the bilateral trading agreement.

The lack of political will have an impact in making sure that foreign countries do not pay for services rendered. Other organizations such as OECDs are strongly ensuring that corporation agreements are followed properly and that there is proper trading between countries that are in corporation. The lack of political will has resulted in many South African companies losing money when trading with foreign neighbouring companies such as Nigeria, and Mozambique.

The seventh primary challenge is weak planning for long-term capital power-infrastructural investment in power utilities. This weak planning encompasses skills and capacity development, financial planning and budgeting and financial control. In most of the municipalities, skills development is lacking, resulting in outsourcing production of services to consultants at a high cost. This result in increases in power utilities' capital spending, progressive lack of internal capacity and failure to withstand future power demand. In order for the power utility to meet its demand, it has to raise the loan that increases its debt payment at the higher rate. In the process of servicing the loan, the power utility is compromising spending money in grid maintenance. Most power utilities in developing countries do not have compelling revenue collection strategies.

The eighth primary challenge is lack of Good Corporate Governance, referring back to diagram 6.1. In terms of the fiduciary law, the committee members have to possess a different skill set in order to arrive at the investment decision that will protect their client from possible exploitation by the seller. In this instance, Eskom was informed at a later stage that they would be constructing Medupi, Kusile and Ingula in order to address capital power-infrastructural challenges of South Africa. This was reverse of the government decision taken in 1998 that Eskom will not be constructing power stations as the country was pursuing renewable energy as the future solution. This led to starting of Medupi and Kusile with virtual designs, without proper plans. Some of the power utilities particularly under municipalities end up under their provincial government administration due to financial mismanagement. Msunduzi, for instance, in Pietermaritzburg, the provincial executive has applied section 139 (1) of the Constitution, which describes that when the municipality is unable to fulfil its obligations, the provincial executives can intervene in the form curatorship. South Africa declared surplus capacity of electricity in 2017 but continued to face load shedding in 2019. The reason for load shedding in 2019 was as the result of the power lines that collapsed in Mozambique due to inclement weather that led to disaster in March 2019. The promises made by the Former President Jacob Zuma in 2017, that there will be no load shedding in the future remained untrue.

The additional capacity generated by IPPs in the country became obsolete. Eskom loan agreement with World Bank was to invest in renewable technology with batteries for energy storage. It is on that ground that investment committee members lacked some power stations related skills to make proper decisions,

as investing in the IPPs, Medupi, Kusile and Ingula, with battery storage facilities in substations for peak shaving, at the same time shows that there was a lack of proper prioritization.

Eskom should have avoided risky contracts through turnkey solution and model Point of Total Assumption (PTA), which is the contract used for high-risk contracts. The PTA details the structural approach of risk sharing for cost overrun between the seller and the buyer. It is normal that when anyone is starting to build the house that is required urgently without proper plans, the probability is that cost will overrun. In this case, it was worse as the contract signed in foreign currency and any minor changes when the rand is weaker had detrimental effect on the budget.

Thereafter the accommodation of numerous design modifications while construction was in progress became understandable and the answerable norm, of which in 2019, the Minister of Public Enterprise, Pravin Gordhan declared as bad design and poor construction. These projects that have had cost overrun of more than 530% variance, initially pursued through normal investment management process without engaging more into literature of how to approach construction of high risk, high cost and multi-stakeholder's investments. In such a situation, the business assumed the normal capital investment process suitable in installing the power transformer outside the house. There were no policies and procedures of handling such mega-infrastructure investment, including setting milestones of Critical Success Factors (CSF). It would have been expected that investments such as Medupi that had initial prices of R23 billion but approved with the business case of R45 billion would have sent the signal that the costs were most likely to escalate as they are at R145 billion by January 2019. This means that they have escalated by R100 billion. The ninth primary challenge is demanding contracts. In South Africa, power utilities are mostly using the New Engineering Contracts (NECs). The application of these contractual clauses requires persistent contract monitoring. It becomes complex when there are many contractors involved such as in the case of Medupi, Kusile and Ingula, as they had multi-packaging contracts. In the contract negotiation phase, the engineering companies had already stated to Eskom that they would be providing engineering design, with costing and BOM.

The finding in the literature review is that some of the foreign suppliers involved were doing work for the first time, as not bound by the CIDB grading which is the South African concept of building smaller contractors to become bigger contractors. These foreign suppliers managed to raise capital and delivered as per sign contractual requirements. Whether the design was good or bad, it is outside the limits of this thesis to discuss, as South Africa may have bought what foreign companies were selling. However, it imperative to highlight that there were many compensation events processed during construction stage related to scope changes.

The tenth causality is the lack of knowledge management, and in the corporate world decisions taken have a ripple effect for decades to come. Poor investment in knowledge management is amongst the

reasons power utilities are utilizing foreign globally competitive companies demanding Power Purchasing Agreement (PPA) for renewable energies that is more expensive than for developed countries. As stated earlier that South Africa's PPA has the unit cost price of R2.02/kwh whilst the selling price of 80c/kwh and even worst for solar CSP, as it cost R3.65/kwh with the selling price that is not giving returns. There is a relationship between lack of knowledge management and lack of revenue income. The utilization of foreign companies means expenditure that could have been avoided should knowledge management was adequately applied.

However, due to lack of Coopetition Project Structures (CPS), there is also a lack of organizational tacit knowledge, and the ability to manage proposals or modifications made by foreign companies becomes impossible. The costs overrun in the single investment stealing an opportunity of further capital power-infrastructure investment leading to inability to meet power demand. If South African government applied knowledge management, it should have reached an agreement with international renewable energy companies and deployed certain people to learn renewable energy as early as 1998, and that would have avoided PPAs with the unit cost of R2.02/kwh and sell for 80c/kwh.

NERSA regulations of power purchase price for generation of power, transmission of power and distribution whilst coal cost increases beyond industry norms for power utilities. This means that when transmission division is buying from generation division, the unit/kwh for national supply or international transmission increases in order to be profitable due to the impact of coal cost.

This drives tariff increases, which will in turn increase inflation. Electricity is key in economic growth and sustainable development of the country. Although South Africa was initially designed to be able to provide electricity at the cheapest price in order to make South Africa business viable. The cheapest electricity is amongst the challenges that has led to revenue income deficit, which has led to inability to invest in the development power-infrastructure. In terms of electricity act, licensed power utilities have to comply with voltage regulation requirements in the grid. In other words, the power in the plug socket in the wall has to be known, such that the voltage expected to be 230V, for low single-phase voltage.

The grid code compliance states that in term of power distribution license, section 6.1 of (2006 version): "if any licensee fails to meet license obligations; NERSA may withdraw the license at any time of the distribution license". It continues to state that NERSA may serve upon him by post a notice in writing to meet those obligations within 30 days or such longer period as NERSA may determine. Then this license put strict conditions by stating that if the licensee fails to comply with the requirements of the notice; the power utility shall be guilty of an offence and upon conviction be punishable as provided in the Act.

What is interesting is the fact that it continues to state what could be the likely punishment where it states that NERSA may make recommendations to the Minister to authorize an appropriate undertaker to enter upon and take possession of the undertaking of the licensee. There is no contradiction between grid code compliance and OHS Act requirements in terms of electricity act of 2006 on this requirement as it is specific in terms of section 15 of OH&S act, page 177 of Electrical installation. ANY person (including Eskom) who fails to comply with ANY provisions of the regulations shall be guilty of offense and liable upon conviction to a fine or to imprisonment for a maximum period of 12 months.

The relationship between the grid code compliance, OHS Act, Electricity Distribution Act, Customers Service regulation NRS047 and Quality of Supply NRS048 are all intertwined in making sure power utilization safety and satisfactorily. However, this still does not constitute globalization of technology by compromising revenue income. The ninth causality includes inability to develop contractual performance agreements with stakeholders. The most complex stakeholders in all capital power-infrastructure investments are politicians.

These stakeholders get excited when the power-infrastructure is coming to be erected into their own areas or the line that is going to cross through their own country to another country as such opportunity lead to better living condition for his constituency. It means there will be business opportunities that will employ people in the area. In addition, skills transfer and improved knowledge will create opportunities of being employed on a permanent basis and the opportunity means that local businesses will have their sales whether it is the sector of accommodation, renting of construction plant or Personal Protective Equipment (PPE).

However, what makes the matters worst is to deal with unexpected expectations that are not mentioned such as bribery or self-enrichment expectation through the development of capital power-infrastructure opportunity. This is one of the complications, as the tax paying residents have to pay as the cost of erecting capital power-infrastructure increases. If doing business include cost of bribing, it increases the cost of doing business, which will mean inflating costs to pay for the hidden politician, which compromises the value chain process and leads to spending money that should have been used in another capital power-infrastructure investment.

In the long-term investment, the review of literature written by Weber and Heidenreich (2017) specified horizontal, vertical and institutional cooperation as part of working together between competing organizations to develop knowledge. Part of the Cooperation is to develop products cheaper than when the market is saturated. This was strongly emphasized by the participants during the qualitative interview process. In urbans areas, where there is a high number of business professional including government employees that are paying Personal Income Tax (PIC) to South African Revenue Service (SARS). Payment of tax become the priority, and South Africans are paying more tax than the

developed countries such as Mexico and Chile. Therefore, paying this high PIC becomes the priority. This leads to meter bypass and illegal connections, as there is a demand for power at home and for business purpose. High PIC, high costs of electricity prices lead to high inflation whilst NERSA approves tariff increases that are below inflation rates for power utilities (refer to Figure 3.10, Figure 3.12 and Figure 6.2 above). It further leads to over-indebtedness due to poor balance sheet, low credit rating and lack of GDP growth. Inflation leads to lack of inadequate power-infrastructure development due to improper handling of tacit knowledge that escalates containable cost of investments.

The eleventh causality is based on the existing financial models used to assess investment viabilities. Mostly power utilities are using the financial models derived from western countries. As stated earlier, returns trajectories as determined using IRR, ROI and NPVs are not being realized in capital power-infrastructure investments. Power utilities mostly from developing countries are financially constrained compared to power utilities from developed countries such as Rosatom in Russia and Westinghouse in USA. The investment of African power utilities into alternative energy requires Coopetition Project Structural (CPS) approach and application of the Total % of Complexity Factor analysis as presented in Appendix B.7. This is because in Chapter 3, there were findings that intensive stakeholders' expectations management and competitive expertise are amongst factors leading to project success. This was amongst findings by Gatzert & Kosub (2016) in European Union vision 2020 study for cross border mega-infrastructure investments, which was further supported by findings done by Li & Youngho (2015) for cross borderline mega-infrastructure investments between China and India. The Total % of Complexity Factor, as presented in Appendix B.7 will further assist in making investment decisions and to determine the level of resource requirements. The details of how this model will be applied are in Chapter 7. In this Chapter, it is imperative to mention that this is the newly developed model not been considered when constructing the Medupi and Kusile projects. It does consider what has led to cost overrun including virtual designs but also included technical, environmental, stakeholders' complexities. During the literature review, it became eminent that most of the South African trade unions are protective of their employees from the possibilities of retrenchments. The politician accumulates political popularity by giving hope to those that have raised complaints regardless of whether their employment is on contractual basis or permanent. This is the truest complexity in developing countries including South Africa. The IRRs, ROIs and NPVs do not consider those dynamics. In the next section 6.4 the current investment selection criteria and the shortfalls in their long-term power-infrastructure capital investments are presented.

6.5 THE CURRENT INVESTMENT SELECTION CRITERIA

Globally, investors are considering Returns on Investments (ROI), the Internal Rate of Return (IRR) and Net Present Value (NPV) for determination of investment viability (Marchioni and Magni (2018). The formula for calculation of ROI is the costs of total asset ownership (Development cost plus maintenance) divided by the discounting rate. In this section, the details related to investment selection is considering NPV and IRR.

The values used are dummy, used for discussing methodological shortfall of IRR. In Chapter 5, question 25 there was background discussion pertaining IRR, which this section will narrate further. The Modified Internal Rate of Return (MIRR) will be discussed as most of the investments experience modifications for cost overruns.

6.4.1 The meaning of the IRR, NPV and PI done above

This section, presents the preview of two projects, as they appear in section 6.4.2 named as Project A and Project B. Both these projects have different NPV values. The project with higher NPV is the selection priority for investment opportunity. In selection, the project with higher + NPV becomes the investment priority. The calculation of NPVs requires determination of PV cash flows considering the discount factors. The sum of PVs over number of years are considered in relation to the capital outlay. This is used to calculate the Profitability Index (PI). The Profitability Index (PI) is one of the determination criterions used for investment viability. It is calculated by adding PV and divide by capital outlay. The project with higher Profitability Index is selected for investment.

Furthermore, in section 6.4.2 there will be calculations related to IRR, as it is one of the criterions used to assess investment viability. In selecting the investment viability between Project, A and Project B, the project with higher IRR is selected for investment. In the preview on section 6.4.2, Project B had higher IRR of 30.45% compared to 9.48% of project A. This means that Project B is the viable investment compared to Project A. In Chapter 5, Table 5.24, 5.25 and 5.26 the questions asked the realization of envisaged return on investments. Most of the participants responded by stating they strongly agree, agree and neutral that the initial envisaged rate of returns is not realized.

In section 6.4.3, the fundamental challenges related to these financial models are discussed. Most of these challenges are linked to investment complexity factor that is not fully analysed or presented in line with NPV, ROI, IRR and PIs analysis. In all these calculations, even on Project A and B in section 6.4.2, there is not even a single point where complexity analysis made. In both these projects, there is no clear understanding of how stakeholders could impact each project, as the application of the financial model is similar. These are among the challenges realized in infrastructure development.

6.4.2 How to conduct profitable investments selection

In the Table 6.1 is an example of two proposed project investments submitted to the investor for investment decision making. The investor will look at the cash flow, the IRR, NPV and PI for decision-making.

Example 1: What will be better NPV, IRR and PI between two possible investment projects? Both Project A and Project B require the capital outlay of R1000 with the repayment cash flow of 5 years and the discount rate or cost of capital of 10%. The cash inflows are different in terms of repayments as indicated in Table 6.1. Based on calculations, the investor will make investment decision on the project with higher NPV and higher PI.

Table 6.1: The selection criteria using NPV and Profitability Index

Project A				**Project B**			
Year	**Cash flow**	**Discount factor 10%**	**PV Cash flow**	**Year**	**Cash flow**	**Discount factor 10%**	**PV Cash flow**
1	300	0.909	272.7	1	300	0.909	272.7
2	250	0.826	206.5	2	400	0.826	330.4
3	200	0.751	150.2	3	450	0.751	337.9
4	250	0.683	170.8	4	500	0.683	341.5
5	300	0.621	186.3	5	600	0.629	372.54
	1300		986.42		2250		1655.09

Profitability Index = $\frac{\text{Sum of the PVs for Project A}}{\text{Initial Capital Outlay}}$

$\Rightarrow \frac{986.42}{1000}$

$\Rightarrow$ **0.986**

Profitability Index = $\frac{\text{Sum of the PVs for Project B}}{\text{Initial Capital Outlay}}$

$\Rightarrow \frac{1655.09}{1000}$

$\Rightarrow$ **1.655**

The NPV will be the total PV cash flow- Capital outlay

Therefore, for project A;

The NPV= 986.42-1000= -13.58

For Project B

The NPV= 1655.09-1000 = 655.09

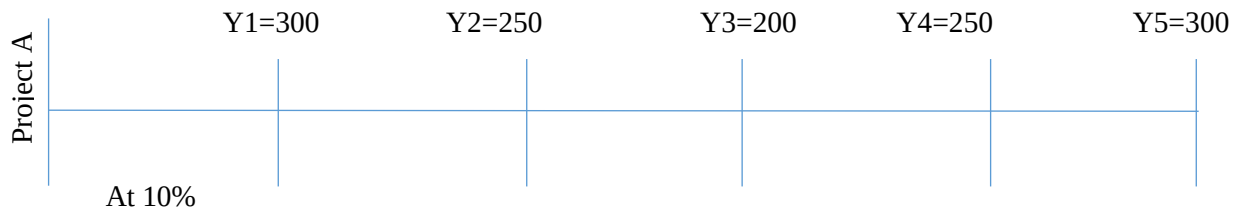
In Table 6.1 above, it demonstrates project A and project B with two different Profitability Indexes (PI) and different NPV. Project A has NPV that is lower than initial capital outlay (-13.58) and Project B has NPV that is higher than capital outlay (655.09). These projects are mutually exclusive with Profitability Indexes (PIs) that are 0.986 and 1.655 respectively. The project with the higher NPV and higher Profitability Index (PI) will be selected for investment. In the example made above, Project B

has higher NPV and higher PI compared to Project A. Project A has PI that is lower than one, which means it is the risk investment. It is understandable that someone may argue that 0.986 is almost one when rounding off the number. However, indexes are operating with precisions. This is still making doubts in terms of investment decisions.

The second investment assessment is IRR. In example 1, the discount factor represented the depreciation monetary value of future cash trajectories into year zero. This does not tell at what discount rate NPV will be zero. In other words, the realization of IRR is when there is a balance between the Present Value (PV), the cash flows and Future value (FV), the cash inflows, the annual payment returns.

Diagram 6.11: The demonstration for the calculation of IRR, select project with better returns

Starting with Project A; using values from Table 6.1 above in order to determine the IRR.



In calculating IRR, the cash outflow has to be equal to the cash inflow, which is when NPV will be zero.

Cash out flow (Initial Capital outlay, which is -R1000) = Cash inflow, that is the money that will be received on yearly basis, as indicated as Y1, Y2, Y3, Y4 and Y5, assuming that the discount factor is 10%.

Cash outflow = Cash inflow= Zero, NPV for Project A.

$0 = \text{Cash outflow} + \{(PV_{(Y1)} \times (1 + r)^{-1}) + (PV_{(Y2)} \times (1 + r)^{-2}) + (PV_{(Y3)} \times (1 + r)^{-3}) + (PV_{(Y4)} \times (1 + r)^{-4}) + (PV_{(Y5)} \times (1 + r)^{-5})\}$

Plugging in real cash flow values for project A:

$= -1000 + \{(300 \times 0.909) + (250 \times 0.826) + (200 \times 0.751) + (250 \times 0.683) + (300 \times 0.629)\}$

$= -1000 + \{(272.7 + 206.5 + 150.2 + 170.75 + 186.27)\}$

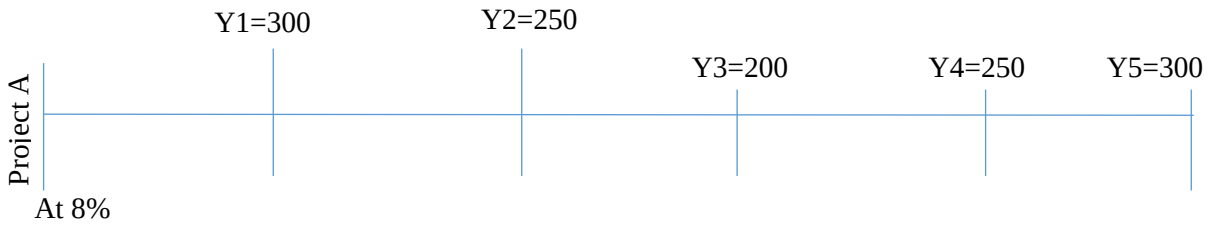
$= -1000 + 986.42$

$0 \neq -13.58$

NPV = -13.58, Left Hand Side is not equal to RHS

The next thing to do is to increase NPV until it reaches zero by decreasing the discount factor as depicted in diagram 6.3 below. Basically, this is how this works, 10/5= 2 but 10/2=5. This means that the way to increase 2, is to reduce the denominator. In the case of the example made it will be reducing the discount rate from 10% to some value that will give the NPV which is zero.

Diagram 6.12: **Drawn for the depiction of 8% as the discount factor to assist in NPV calculation**



Applying the very same approach

$0 = \text{Cash outflow} + \{(PV_{(Y1)} \times (1 + r)^{-1}) + (PV_{(Y2)} \times (1 + r)^{-2}) + (PV_{(Y3)} \times (1 + r)^{-3}) + (PV_{(Y4)} \times (1 + r)^{-4}) + (PV_{(Y5)} \times (1 + r)^{-5})\}$

$= (-1000 + \{(300 \times (1.08)^{-1}) + (250 \times (1.08)^{-2}) + (200 \times (1.08)^{-3}) + (250 \times (1.08)^{-4}) + (300 \times (1.08)^{-5})\})$

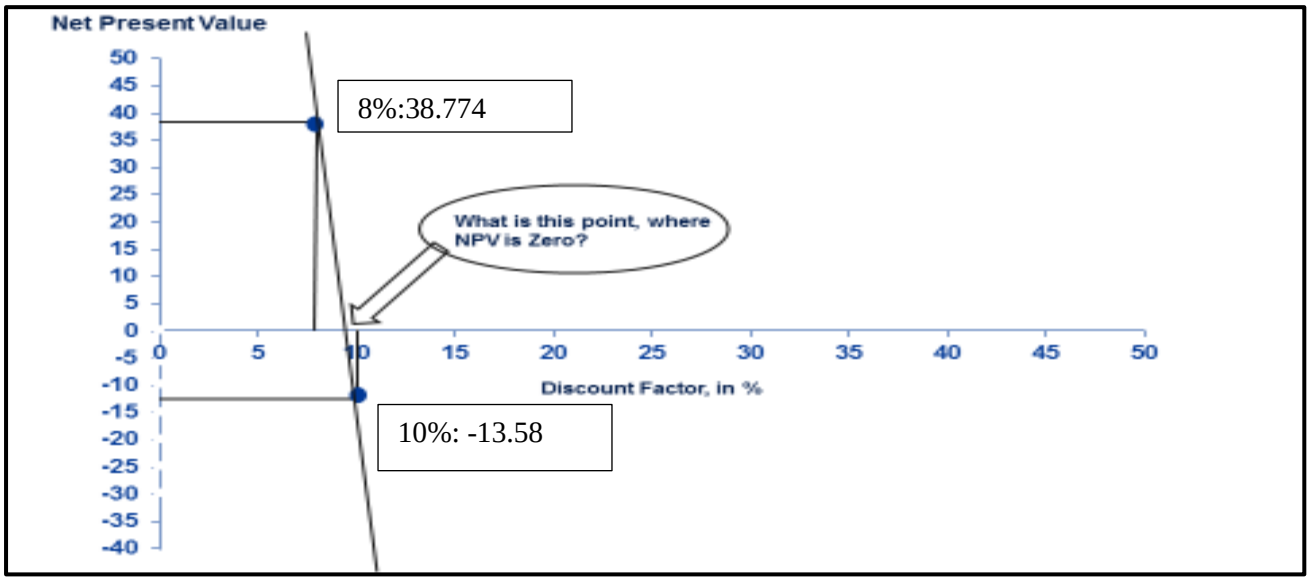
$= \{-1000 + (300 \times 0.926) + (250 \times 0.857) + (200 \times 0.794) + (250 \times 0.735) + (300 \times 0.6805)\}$

$= -1000 + 277.80 + 214.25 + 158.8 + 183.75 + 204.174$

$= 38.774$

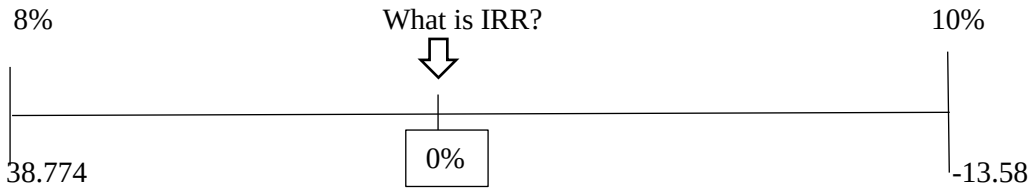
At the discount rate of 8%, the NPV is 38.77. This is now higher than zero, as indicated in the following diagram 6.2.

Diagram 6.13: The discount factor and NPV, with the intention of determining the IRR



The above diagram 6.4, illustrates that the value of the NPV when the discount factor is 10% is -R13.58. It further depicts that when reducing the discount factor from 10% to 8%, the NPV increases to be R38.774. In the section is the calculations of determining the actual value of the IRR when the NPV is Zero. Continuing with trial and error method will consume time, as all discount factors will have to be tested until NPV is Zero. The easiest method is to apply arithmetical calculations, which gives IRR in the quickest form using diagram 6.5 below.

Diagram 6.14: **Arithmetical approach towards determining the IRR where NPV is Zero**



In diagram 6.5 above, starting from the left, there are discount rates at the top of the lines and corresponding NPVs at the bottom. In the center of the line is zero representing the NPV. Calculations are to determine what will the IRR.

There are 6 steps to follow:

1. The first step is to subtract the lower NPV from the higher NPV as in the following

= 38.774- (-13.58)

= 38.774 + 13.58 = R52.354

This could be interpreted as the distance or values between discount factors.

2. The second step is to subtract the lower discount factor from the higher discount factor as in the following:

= 10%- 8% = 2%

This is the difference between two discount factors that are both on the sides of NPV zero.

3. The third step is to present NPV versus discount factor relative analysis as in the following:

Difference of NPV: Difference of discount factor

52. 354: 2%

4. Take the higher NPV to determine the probability of determining what could be the value of IRR in this case it will be 38.774. This value will be used to determine IRR.

5. The fifth step is to solve what will be x (solve for X).

R52.354: 2%

38.774: X

Cross multiply

= X * 52.354 = 2% x 38.774

$X = \frac{2\% \times 38.774}{52.354}$

X = 1.48%

6. The sixth step is to add the above percentage value (1.48%) to the lower discount factor.

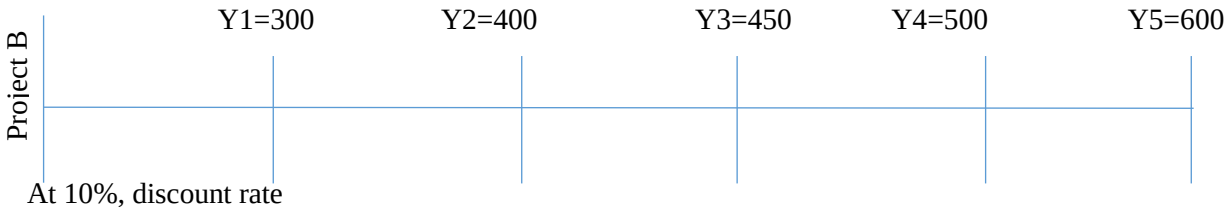
8% + 1.48% **= 9.48%.**

Therefore; the IRR for Project A, when NPV is Zero is 9.48%.

This is the IRR for project A. This IRR is below the cost of capital, at the initial discount factor of 10%. This indicates that Project A is not viable project for investment in terms of financial security. It is the loss of investment capital.

In the next section, is to determine IRR for project B in order to arrive at an investment decision making. There will be repetition of similar process done in project B. The naming of the project A is not specific. In the following diagram 6.6, analysis is made for Project B with the values stated in Table 6.1 above.

Diagram 6.15: Project B using values from Table 6.1 above in order to determine IRR



At 10%, discount rate

At 10%

0 = Cash outflow + {($PV_{(Y1)}$ x $(1 + r)^{-1}$) + ($PV_{(Y2)}$ x $(1 + r)^{-2}$) + ($PV_{(Y3)}$ x $(1 + r)^{-3}$)+ ($PV_{(Y4)}$ x $(1 + r)^{-4}$)+ ($PV_{(Y5)}$ x $(1 + r)^{-5}$)}

Plugging in real cash flow values for Project B at 10%:

= -1000 + {(300 x 0.909) + (400 x 0.826) + (450 x 0.751) + (500 x 0.683) + (600 x 0.629)}

= -1000 + 272.7+ 330.4 + 337.95 + 341.50 + 377.40

= 659.95, this is the NPV when discount rate is 10%.

$0 \neq$ R659.95

This is the very big NPV; it has to come down to zero. In order for this to come down, the discount factor will have to increase.

In this case, it is different from Project A, when NPV was -R13.58 and had to increase by reducing the discount factor from 10% to 8%. In this case the NPV is high and to reduce it, the discount factor has to increase. Using the trial and error method, trying 12% is also logically acceptable.

At 12%

= (-1000 + {(300 x $(1.12)^{-1}$) + (400 x $(1.12)^{-2}$) + (450 x $(1.12)^{-3}$) + (500 x $(1.12)^{-4}$) + (600 x $(1.12)^{-5}$)})

= (-1000+ 267.9 + 318.8 + 320. 265 + 318 + 340.2)

= R565.165

$0 \neq$ R565.165, this NPV is still very high.

The application of the arithmetical analysis using the same approach as that applied in diagram 6.4 above will be very complex. In this case, NPV zero will be on the side, not in the centre as it was the case in diagram 6.4. It is clearer that the discount factor will be very high. In the following diagram 6.4, is the graphical illustration for discount factors of 10% and 12% and representation of NPV values as determined above.

Diagram 6.16: Reduction of NPVs for Project B when discount factors increase

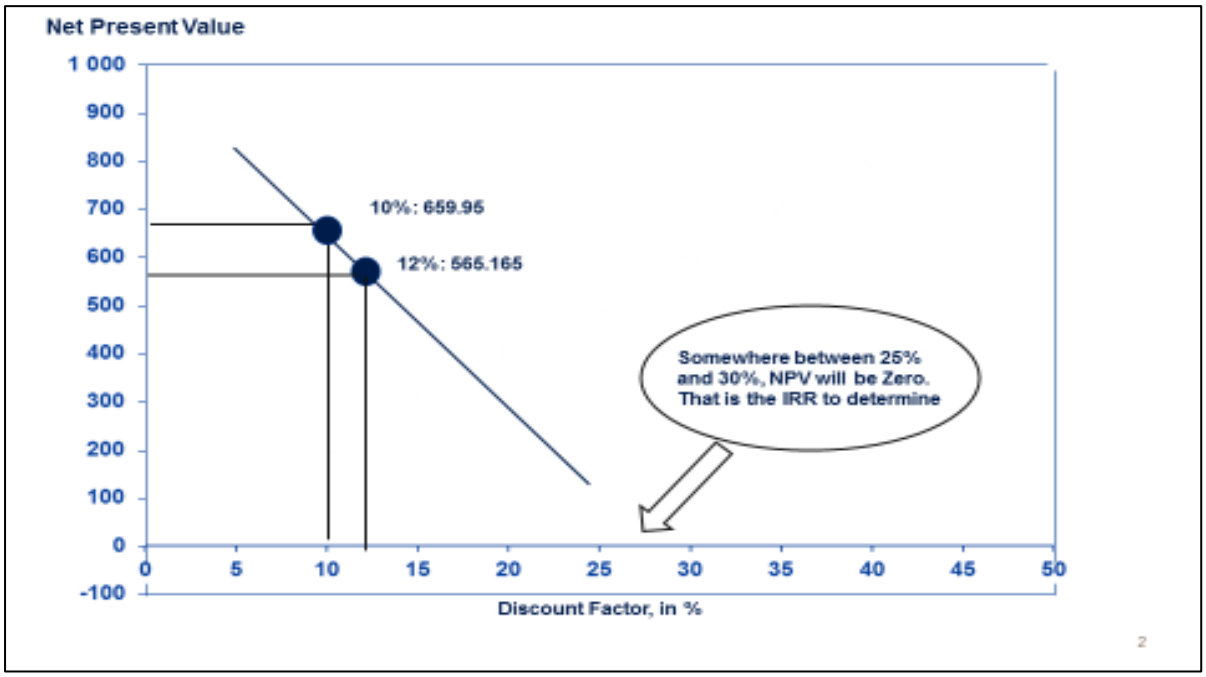


Diagram 6.7 above, depicts reduction of the NPV when the discount factor increases from 10% to 12%. The NPV values reduce from R659.95 to R565.165 respectively. The simulation using diagramming technique to determine where the NPV could be zero, points between 25% to 30%.

In this scenario, diagram 6.4 will be applied in reverse as stated earlier that NPV (Zero) is expected to be outside of the tested discount factors, as stated earlier. There are no records demonstrating how to calculate IRR when both tested discount factors are either on the positive or negative side of the zero. The demonstration for this is the following diagram 6.8 below.

Diagram 6.17: Procedure to find IRR when two discount factors are lower than required IRR

In the similar review of the technique used in diagram 6.4. In diagram 6.7, the recorded highest NPV is R695.95 until arriving NPV of zero. Looking at the existing numbers, the difference of NPV of 10%, R695.95 and NPV of 12%, which is R565.16 is calculated below as follows:

= 659.95 – 565.16= R94.785.
The difference in the discount factors is 2%.

The application of arithmetical analysis to determine IRR in diagram 6.4, follows the similar procedure used to determine IRR in diagram 6.3. This will be achieved in the following steps:

1. The first step, is the total difference from higher NPV to zero which is R659.95.
R659.95: X (which is related %)

However, between 10% and 12%, is 2% difference giving the NPV 94.785. Then the cross calculations

R659.95: X (which is related %)
94.785 2%

Then:

$$X \text{ (which is related \%)} = \frac{2\% \times R659.95}{R94.785}$$

Answer is X = 13.93%, rounding it up to 14%.

Note; previously because Zero was between two discount factors and then to determined X was added to the small discount factor. In this instance, it will be added to the bigger discount factor, which 12%.

12% + 14% =26%. Therefore, the IRR where NPV will be zero will be around 26%.

Now, it is imperative to double check this arithmetical analysis, this will be through plugging the actual values on the formula in order to check if cash outflow = cash inflow=zero

At 28%

$= (-1000 + \{(300 \times (1.28)^{-1}) + (400 \times (1.28)^{-2}) + (450 \times (1.28)^{-3}) + (500 \times (1.28)^{-4}) + (600 \times (1.28)^{-5})\})$

= (-1000 + 234.375 + 244.14 + 214.58 + 186.25 + 174.62)

= R53.89. The discount factor has managed to drop down NPV from 659.95.
$0 \neq$ R53.89

It will be improper to make assumptions that this is due to rounding up numbers during calculations. What happens when using the discount factor of 29%?

At 29%

$= (-1000 + \{(300 \times (1.29)^{-1}) + (400 \times (1.29)^{-2}) + (450 \times (1.29)^{-3}) + (500 \times (1.29)^{-4}) + (600 \times (1.29)^{-5})\})$

$= (-1000 + 232.56 + 240.37 + 209.62 + 180.55 + 167.96)$

= The NPV is 31.05, this is still not zero.

$0 \neq R31.05$

To further reduce the NPV, it means the discount factor need to continue increasing. What if the discount factor is **at 30%?**

$= (-1000 + \{(300 \times (1.30)^{-1}) + (400 \times (1.30)^{-2}) + (450 \times (1.30)^{-3}) + (500 \times (1.30)^{-4}) + (600 \times (1.30)^{-5})\})$

$= (-1000 + 230.769 + 236.686 + 204.824 + 175.06 + 161.597)$

The NPV value is 8.9. This NPV is dropping but still not yet zero so that the LHS = RHS.

$0 \neq R8.9$

What about the discount factor of 30.4%?

$= (-1000 + \{(300 \times (1.304)^{-1}) + (400 \times (1.304)^{-2}) + (450 \times (1.304)^{-3}) + (500 \times (1.304)^{-4}) + (600 \times (1.304)^{-5})\})$

$= (-1000 + 230.0613 + 235.236 + 202.945 + 172.925 + 159.134)$

<u>The NPV Value is 0.3 which is still not exactly equal to zero</u>.

What about the discount factor of 30.5%?

$= (-1000 + \{(300 \times (1.305)^{-1}) + (400 \times (1.305)^{-2}) + (450 \times (1.305)^{-3}) + (500 \times (1.305)^{-4}) + (600 \times (1.305)^{-5})\})$

$= (-1000 + 229.885 + 234.876 + 202.479 + 172.396 + 158.525)$

The NPV value becomes -1.83.

The higher the discount factor, the more negative is the NPV. When increasing the discount factor, the NPV decreases and becomes even more negative. Trying these numbers takes the long time, making the last calculation by increasing the discount factor to 31% will not make much of the difference. This

is just to test what will happen to the NPV when increasing the discount factor further. The expectation is that the NPV will be zero.

Discount factor at 31%

$0= (-1000 + \{(300 \times (1.31)^{-1}) + (400 \times (1.31)^{-2}) + (450 \times (1.31)^{-3}) + (500 \times (1.31)^{-4}) + (600 \times (1.31)^{-5})\})$

$= (-1000 + 229 + 233.086 + 200.169 + 169.779 + 155.52)$

The NPV is now -12.

The NPV became more negative.

The final determination for IRR of Project B, achieved when NPV is zero at approximately 30.4% or 30.45% but just before 30.5%. When referring back to diagram 6.4, the approximation was close and good enough. The arithmetic analysis and trial and error method contributed to what the mostly likely of what the IRR could be.

6.4.3 The challenges related to existing current financial models

There are three challenges related to these financial models. The first when looking at diagram 6.4 above, there is lack of understanding who is the beneficiary of the internal rate of return between the investor and the borrower, the power utilities. The answer is that these IRRs are for the benefits of the investors. The application of the IRR is such that the investors such as the World Bank and IMF will want to drive for the higher IRRs as part of their financial security. However, the power utilities as borrowers want to secure lower interest rates.

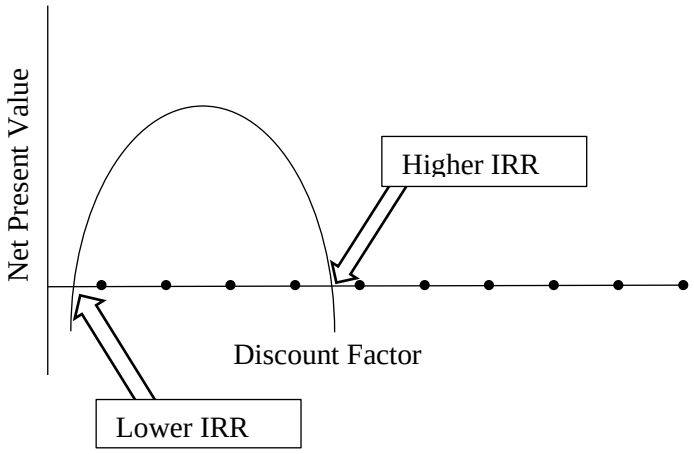
In diagram 6.7 the graphical plot from discount factor 10% to 12% created trajectories as if the NPV was most likely to be zero when the discount factor is somewhere between 25% to 30%. The trajectory of diagram 6.7 may have created an estimation that at 30%, the NPV was already going to be negative (refer to diagram 6.7 above again). Further to that, the arithmetical calculations revealed that the NPV will be zero at 26%.

The arithmetical analysis can be interpreted as confirmation of trajectories making use of diagram 6.7. It is most likely that investors would have taken the decision to invest accepting 26% as the appropriate IRR, whilst it is not true when applying trial and error method, IRR is mostly to be around 30.45%. It is clearer that these financial models can give multiple IRRs.

The second challenge is the linear assumption that the increase or decrease in the NPV is based on the linear increase or decrease in the discount factor will remain linear. When reviewing both diagram 6.4 and 6.7 lines, the estimated assumptions can be made where the IRR could be. This is when assuming that this will be a straight line.

These assumptions are as such that there will be no global recession, no economic sanctions, or no political instability that could lead to difficulty in financial repatriation, the inflation rate will remain fixed and foreign exchange rate or financial risks will remain as per initially assumed. When starting to apply various scenarios for investment decision, multiple IRRs get realized as in the case depicted in diagram 6.9 below.

Diagram 6.18: Scenario where there could be multiple IRRs



In the above diagram 6.9, the depiction of multiple IRRs presents the challenge that there is no direct knowledge of the correct IRR to use. In such instances the recommendations are to revert to the application of the NPV. The NPV itself presents the shortcoming that it uses a single discount factor.

There have been many calculations done to calculate the NPV in this study. The reality is that NPV has rendered itself to be irrelevant unless it presents both cash outflow and cash inflow in order to arrive at breakeven point. The realization of the IRR requires the normal cash flow process. This means that for rate of returns to be deemed viable, there has to be capital outlay (cash outflow) that should be justified with assumptions of the possible returns (cash inflow). This is less practical in large capital investment, as cash outflows continues even if certain parts of the power-infrastructure are in commercial operation.

The third challenge is that calculations of IRRs are a tedious and complex process to understand, yet when appropriately applied, there is still uncertainty of investment returns. This uncertainty is what Eskom and all other state-owned companies in South Africa has declared as the challenge but without creating the solution to it. If capital investments are mutually exclusive with project A with high returns but low NPV and project B with low returns but high NPV. The investor will choose value maximization (NPV) by reducing the discount factor.

The cost overruns during capital infrastructure development lead to revisions in order to generate new Estimate to Complete (ETC). This renders IRR to be inappropriate, as additional money has to be re-

invested. The Modified Internal Rate of Returns (MIRR) becomes more appropriate when knowing the cost of capital. This MIRR still becomes relevant in countries where there is political and economic stability, where revenue income is as per initial trajectories. In most of the power utilities, and investments done in industrial developed urban clusters are unable to recover initial forecasted revenue income.

6.6 THE NEW POWER UTILITIES' APPROACH TOWARDS BUSINESS GROWTH AND SUSTAINABILITY

The literature review indicated that there have been many power utilities privatized in developed countries. The privatization of State-Owned Entities (SOEs) becomes a political and economic issue in South Africa (Vavi, 2008 and Jim, 2018). In the literature, private power utilities face resource constraints unlike SOEs. This leads to poor quality of power service resulting in low economic growth and an increase in unemployment levels. In South Africa, there will an opposition by labour unions in the privatization of power utilities (Jim, 2018). However, power utilities are collapsing due to lack of revenue income with consumers such as SOWETO and private companies tempering with meters or bypassing meters and Municipalities debts (R46.1 billion) (Writer, 2020).

The application of systems thinking reveals that lack of revenue income leads to inability to meet stakeholders' expectations in terms of power quality, inability to meet power demand in terms of energy security, safety compromise leading to non-compliance (review Section 3.6.3). The review of Section 3.7 on the study by Boero et al., (2019); Section 3.12 on the study by Pal et al., (2017) and review Section 5.4 indicates that South African power utilities need to consider foreign investment and equities instead of bonds acquisitions. SOWETO for example is a complex bulk-supply consumer, which is highly politicized, in defiance to pay and are disputing to pay debt of R18 billion to Eskom (Bahudur, 2020). The only way to recover this debt will be to sectionalize the area to the foreign investors who will ensure adequate power supply, revenue income recovery and Eskom will have to get equities. There is discussion related to this in Section 7.4.1, Sectional Power Asset Undertaking.

In the literature, the approach of apartheid government (pre-election of 1994) versus democractic government (post-election of 1994) was discussed that power-infrastructure development changed from focusing on economic growth (pre-1994 election) but it also focused on social and economic growth (post 1994 election). The current IRRs, ROIs, and NPVs used to justify investment returns in power-infrastructure developments for both rural and urban arears needed further justification, considering High Court case No CASE NO: 1477/2013, 1778/2013 and 1482/2013 that was in 2013 in King Sabata Dalidyebo (KSD). It is for that reason a Total % of Complexity Factor which will determine how complex are the stakeholders, the rate of consumers' payment in the area should also be considered.

6.7 CONCLUSION

The presented systems thinking as initially demonstrated in the theoretical framework in Chapter 2. In this chapter, systems thinking managed to analyze and list 10 challenges together with their cascaded interrelatedness leading to challenges in capital power-infrastructure investment. The chapter further illustrated that beside known corruption in various power utilities, holistic analysis presented uncertainties in resolving complex revenue-income challenges in South African power utilities.

The major reason why Eskom has financial challenges is systemic. In this chapter, systems thinking never found unbundling of power utilities as the solution. The chapter further found that vertical integration of power utilities towards government and alignment to the ruling party compromises revenue income. This becomes both capital and operational intensive for government's limited financial resources. In other words, this chapter presented the clear understanding that unbundling of Eskom, as presented by Cyril Ramaphosa, the President of South Africa, on the State of Nation Address (SONA) held on the 07 Feb 2019 in Cape Town, was not going to solve power utility's financial challenges. The turn-around strategy for Eskom from liquidity to equity can be through enforcing timeous revenue income. The chapter further presented that the existing financial models such as NPV, ROI, IRR, PI and MIRR are among challenges, as they are not realized. This study justified the need for further analysis by highly introducing Sectional Power Asset Undertaking and Total % of Complexity Factor.

The revenue recovery challenge is facing most of the state-owned companies in South Africa such as SAA, SABC, Transnet and so forth. In this, the chapter demonstrated that application existing financial models excludes investment complexity factors. The supply-chain management policies including SD&L are among contributors of cost overruns. In order for SD&L to have beneficial skills transfer effects, the revision on the approach requires implementation. There was demonstration that these financial models are mostly for the benefit of the lender not the borrower. Further to that, the chapter presented that among reasons power utilities in developing countries liquidates is globalization. This globalization includes improper due diligence towards renewable technology as the solution towards energy mix. The fast development towards being global competitive without adequate steady revenue income to sustain business cash flow is capital intensive. In order to realize steady income cash flow, lessons from global trading companies such as China need to be sort. The bilateral trading agreements in developing countries such as SADC in Southern Africa needs enhancement. There are lessons to learn from cooperation agreements such as OEDC, and OPEC.

The next, Chapter 7, presents recommendations and conclusions, first it reviews the past versus the current reality as stated in Chapter 1 and further reviews each research question and objectives if has been fulfilled before making recommendations. It then concludes by making the conclusions of the entire study.

CHAPTER 7

RECOMMENDATIONS AND CONCLUSIONS

7.1 INTRODUCTION

The aim of the study was to investigate how the application of systems thinking can minimize losses in capital power-infrastructure investment in South Africa. As indicated in the first chapter, this aim was to be achieved by answering the research questions stated in section 7.2 below. After answering these research questions, the chapter then provides the recommendations.

7.2 THE RESEARCH QUESTIONS

- What could be the challenges regarding development of power-infrastructure capital investments in South Africa?
- What impact would timeous payment by debtors have in capital power-infrastructure investments in South Africa?
- What would be the extent of investment opportunities lost due to costs escalations using stakeholder analysis?
- What could be the systemic model formulated to evaluate the long-term power-infrastructure investment in South Africa?
- What systems thinking could determine as an impact that the procurement of long lead goods and contracting of foreign skills have on projects?

7.3 ANSWERS TO THE RESEARCH QUESTIONS

There were five research questions that the study sort to answer and these questions are as stated and answered below. The answers are based in literature review and data collected from both quantitative and qualitative research.

- **What could be the challenges regarding development of capital power-infrastructure investments in South Africa?**

The answer to the above question, as broadly discussed in previous chapter, is based on five sub-questions that were posed in the questionnaire and a broad question that participants had to answer during the interview session. The study, amongst other things, indicated that the challenges regarding

capital power-infrastructure investment include inadequate scope during concept phase and that this leads to variations during execution phase, and the cost basis of the project(s) which does not fulfill the entire capital power-infrastructure investment requirements. The study also revealed that resources such as engineers with the knowledge in the design and construction of power stations were no longer available. This chapter also indicated that poor supply-chain management policies that do not have adequate skills development strategies. Furthermore, study further revealed that disagreements of stakeholders and their power exercise was among challenges of capital power-infrastructure investments.

The research discovered that since major power utilities such as Eskom and Johannesburg City Power stopped building power stations there was reduction in domestic coal purchases by South African government. This resulted in mining sector increasing their export to Western and Asian countries in order to generate revenue income for their business sustainability.

The research found that among causes that led to power-infrastructure capital investments included lack of adequate expertise in the composition of governance committees, the high frequency of changes in the executives of Eskom, which led to inadequate definition of long-term organizational strategic intents. Moreover, the research found that lack of political-will to address power utilities' revenue income was among challenges. The vertical integration of power utilities with government and their alignment with the ruling party were amongst other challenges, together with governments' inability to attract foreign direct investments with low interest rates for payment was also discovered in this study.

As mentioned in the previous chapters that power utilities are performing like the roller coasters, the study discovered that some of the causes for this include inadequate definition of long-term organizational strategic intent, insufficient time spent on upfront planning, over-investment on non-core asset. The study further discovered that when the power utility prioritizes globalization more than focusing on its revenue income, it leads to poor financial performance. Lastly, the study discovered that the inability to ascertain the construction complexity where construction takes places leads to cost overrun and complexity of execution.

- **What impact would timeous payment by debtors have in capital power-infrastructure investments in South Africa?**

The answer to the above question, as broadly discussed in Chapter 6, has been based on five sub-questions posed in the questionnaire and a broad question that participants had to answer during the interview session. Amongst other things, the study discovered that enforcing revenue income on

diplomatic relations with the neighboring countries could have timeous impact for power utilities. Further to that, the study discovered that inability to enforce power-purchasing agreements more particularly on the cross-border power supply has lost its value.

In the study, it was also discovered that switching off South African townships and large power users owing power utilities would enforce payment and impact positively on power utilities revenue income. The study further discovered that the fine amount charged by power utilities to customers when tempered with the meter is too small to impact on power utility's poor revenue income. Lastly the study discovered that education regarding tariff cross subsidization will have positive impact on power utilities' revenue income.

- **What would be the extent of investment opportunities lost due to costs escalations using stakeholder analysis?**

The answer to the above question, as broadly discussed in Chapter 6, has been based on five sub-questions posed in the questionnaire and a broad question that participants had to answer during the interview session. This study found leading to investment opportunity lost are as the results of cost escalation. The study discovered that some money that could have been invested in developing new infrastructure is used during cost increase variations.

The study further found that amongst other things that power utilities could do to reduce the extent of their capital- power-infrastructure investment challenges, would be to deploy their officials into key stakeholders' premises. The study further found that Project Managers or Leaders should compact their stakeholders when executing the capital investment in order to reduce the lost opportunity extent that will be caused by stakeholders that are power playing including employment of contract workers during the EPWP program.

- **What could be the systemic model formulated to evaluate the long-term power-infrastructure investment in South Africa?**

The answer to the above question, as broadly discussed in Chapter 6, the answer has been based five sub-questions in the questionnaire, the literature review and qualitative research question. It is imperative to state that the research question sort to determine the systematic model that could be used to evaluate the long-term power-infrastructure investments in South Africa, the answers that were provided by the participants as well as the literature review that was consulted necessitated the formulation of more than one model.

The first model that was deemed appropriate is called Sectional Power Assets Undertaking, distribute and Control , the second model that was deemed appropriate is called Total % of Complexity Factor and the third model is how the IRR can be found when the discount factor is either reducing or increasing slow away from or close to zero. Lastly and more importantly is the application of systems thinking in reviewing the capital power-infrastructure investment that was found suitable.

- **What systems thinking could determine as an impact that the procurement of long-lead goods and contracting of foreign skills have on projects?**

The answer to the above question, as broadly discussed in Chapter 6. The answer has been based on sub-questions posed in the questionnaire and a broad question that participants had to answer during the interview session. Amongst other extents, that this study discovered is the procurement of goods and services from foreign countries as the cause leading to the delay and an increase in the Interest During Construction (IDC).

The study further discovered that the South African labor rights to strike increases freight insurance and increases investment delay costs. Moreover, the study discovered that the environment of operation such as regulating laws of contracting, the Supplier Development and Localization, Original Equipment Manufacturing (OEM), contractual agreements and local community expectations contributes to the delays in capital power-infrastructure investments.

The study discovered that the procurement process is such that the contract signed between the buyer and seller get manipulated by the seller in order to make more profit. The study further discovered that the foreign suppliers are not playing supervisory role in order to ensure that skills get transferred. The local suppliers remain behind unable to deliver what the foreign company was meant to develop them to deliver.

7.4. MODELS THAT CAN BE USED TO IMPROVE POWER-INFRASTRUCTURE CAPITAL INVESTMENT

There are three models that the study considered as the requirement in order to address power utilities' challenge on capital power-infrastructure investments.

7.4.1 Sectional Power Assets Undertaking, distribute and Control

In Chapter 3, Figure 3.7 and Figure 3.10, the study presented the decline in municipal infrastructure investment and Eskom respectively, demonstrating the dire situation in all South African vertical integrated power utilities. Based on the literature and the sensitivity of privatization in South Africa. The study is modelling **Sectional Power Asset Undertaking, distribution and Control** as initially

introduced in Chapter 6, Section 6.5. This model is unlike privatization, but it relieves pressure from state; that has to raise capital to replace vertically integrated power-asset under its asset register.

This model has minimal impact on retrenchments particularly on critical skills such as engineers and technicians. It works in the format that section of power distribution is outsourced to the private companies, with the value of underground, on the ground and above ground asset value fully disclosed. All power-infrastructure assets have dates of installation. There is verifiable certainty in the age and asset depreciation value. The private companies will then take over the section and power utilities staff transferred to the private company for the duration of contractual agreement period. The contractor will absorb the employees under its own basic conditions of employment service and in line with labor relations act. At the completion of the contract, employees will return to the power utility.

In Sectional Power Assets Undertaking, distribute and Control, the private company will have an opportunity to improve revenue income by investing in innovative technologies such as automation of household power consumptions. These technologies include ability to control consumption of each household per time of the day. This may include switching off geysers or swimming pools during the specific time of the day. Furthermore, it may include connecting and disconnecting consumers that are defaulting payment.

- This model will reduce government salary bill for the contractual period in that specific section.
- It will improve efficiency to the customer and shift the risk of revenue income due to non-payment by getting equities.
- Employees will acquire skills and improve power utility's working efficiency on their return to the state power utility.
- It will relieve the power utility from constrained OPEX and CAPEX. The contractors' expenditure should be reported on monthly basis so that it will form basis of MYPD process and able to recover expenditure through RCA process.
- The contractor should preferably assess and keep its own stock and when failing buy from Eskom.
- Eskom should sell the obsolete stock items to municipalities that are not as advanced as others in order to clear stock ratio and generate additional revenue income.
- The new capital initiatives such as usage of drones to patrol the lines should be halt; globalization is among reasons power utilities in developing economies are in liquidity crisis.
- Power utilities' fleet of vehicles can be leased to the contractor at the rate that will relieve financial pressure.
- There will be overtime cost reduction.
- Eskom will continue handling customer complaints, power control and demand assessment on behalf of the contractor. This will ensure quality of service by the contractor.

- The contract is not permanent, if there is unhappiness any part can choose not to renew.

7.4.1.1 Advantages of Sectional Power Assets Undertaking, distribute and Control

- This model reduces salary bill from the power utility and the state.
- It increases efficiency as workers learn new skill from the private sector.
- It allows workers for value their employment after they have had an opportunity to be empowered further by the private company
- It creates a stable revenue income for power utility in terms of equities.

7.4.1.2 Disadvantages of Sectional Power Assets Undertaking, distribute and Control

- Dismissed Eskom formal employees by the contractor may return to Eskom after the end of the contract. The engineering practice after dismissal may have dropped. On return, the person can have the choice to proceed with employment or terminating the service.
- The contractor may not attend to certain tasks towards the end of the contract.

7.4.2 Review the application of financial models

- The existing financial models that exist are not explicit of the complexity of capital power-infrastructure investment. There is currently no difference on the IRR, ROI and NPV for the money that could be borrowed to increase road interchange and the money that can be borrowed and expect returns on the power line construction traversing in an undulating terrain. The money borrowed for the construction of substation supplying the township such as Soweto has the same application as the township that is supplying Sandton in Johannesburg or Umhlanga Rocks in Durban.
- The discount factor requires the specification of number of years and CPI adjustments, but it does not include the section of time as the risk factor and political dynamics. For instance, doing business in Uganda, Sudan, DRC and Zimbabwe is unlike doing business in South Africa because of conducive international relations and corporations.

In Chapter 6, discussions focused on the IRR, ROI, NPV and Profitability Index (PI). There were no specific recommendations made pertaining LCOE introduced in Chapter 3. The calculation of LCOE includes understanding of the application of NPV. The formula for LCOE requires an understanding of the total investment cost divided by the total amount of energy generation requirement as indicated in the following formula 2.

Formula 7.2

$$\textbf{LCOE} = \frac{dy}{dx}\frac{Total\ value\ of\ capital\ asset\ for\ investment\ x\ \lim_{n\to\infty}(1+r)^n}{Total\ cost\ power\ to\ be\ generated\ x\ \lim_{n\to\infty}(1+r)^n},$$

Where the total value of capital asset for investment is equal to CAPEX plus Opex. This is discount factor using total number of years power plant expected to incur both capital and operational costs at a certain rate of cost of capital. The cost of generating the unit in Kwh depends on technology used such as water, solar, coal, OCGT etc. The demand for generating KhW depends on both economic and load demand. In this, the power plant size matters. The rural power development cost such as development of 80MVA substation capacity to supply town differs from mega power plant such as Medupi, Kusile and Ingula. It is for that reason there is a need to understand the cost of energy to be generated per power plant overtime.

The current shortfall in the application of the LCOE and all other financial models is the application of all other financial models. It does not consider infrastructure development complexity including difficulty that could be as the results of stakeholders' contribution. In the following formula 7.2.1, the study progresses from formula 7.2 by introducing the combination of the application of LCOE together with compacting the stakeholders, environmental consideration to ensure that total assessment before investment.

Formula 7.2.1

$$f(\text{x}) = \sum_{n=1}^{\infty}\left(total\ \%\ investment\ complexity\ factor\right)\ \text{x}\ \left(\frac{Total\ value\ of\ capital\ asset\ for\ investment}{Total\ cost\ of\ power\ to\ be\ generated}\right)$$

Where X= Capital Power-Infrastructure Investment, (CPII).

- Total % of Complexity Factor, **as depicted in Appendix B7, page 258** means factors such as stakeholders, environment, political, revenue income, safety and technical factor.
- Total value of power asset for investment= Total value of power asset ownership, in Rands
- Total cost power to be generated= the total amount of power to be generated, in Kwh or Mwh.

7.4.2.1 Understanding Total % of Complexity Factor

The total % complexity factor (**as depicted in Appendix B7, page 258**) is the average output related to both internal and external stakeholders, political related complexity, environmental knowledge and criminal nature in the area. The aggregate score determines whether the investment is good to undertake with less possible risks, whether risks are moderate or risky are extremely high, avoidance and at the extreme the rating can lead to the decision of not doing the project at all. The model works with the parameters where low % complexity factor is good with the score of less than 50%. The moderate scale is the score of more 50% but less than 60%.

The risk scale for investment is when the score exceeds 60% but less than 80%, the avoidance is when the score exceeds 80% but less than 90%. When the risk ranking is above 90%, the ranking and results highlight the "Do not do it" as illustrated in appendix B.7. The KPA ratings are weighted at the 20%. The measure, ranking and weighing of the KPAs depends on the agreement of the stakeholders. The Project Manager may view the stakeholders as 40% or may see organizational investment differences as the key issue that could lead to delays that could attract more costs or may see delays of environmental issues as the factor that could require more attention. This should not be a "thumb-suck" but should be well details in terms of engagements.

These weightings have elements that will need to be considered in order to give the total investment assessment. The lower is the total % of investment complexity the better, but the higher is the complexity the worst until where the decision is "Don't do it". In other words, continuing to execute that infrastructure investment means it is most likely to cost a lot of money and an extremely long delay. Appendix B.7 is subjective to the person who was completing the table. Therefore, it is recommended that the project team must engage when populating data on this table, so that it will diffuse subjectivity.

How does this table work? Take for example Key Performance Area called **Internal organizational investment differences.** The aim is to assess the impact of **Internal Stakeholders** and it has the **weighting of 20%.** There are five Key Performance Indicators (KPI) to be used to assess the impact of stakeholders namely:

- Business related strategic priority ranking,
- Design delays related impact,
- Possible scope change on execution,
- Capital process budget-approval delays
- Asset construction related complexities.

Each of these KPIs has the criteria of measurement and in this case, assessment measurement has to be in percentage. Note that for assessment there has to be a source of evidence. In the case of "**Business**

related strategic priority ranking" the source of evidence has to be **Prioritization ranking report**. This KPI has its weighting of 20% to the total weighting weighed by 20% of internal stakeholders (refer to Appendix B.7). This is the percentage rating of each complexity factor for each KPI, which will populate the score immediately by multiplying with KPA weight.

The investment complexity rankings such as "Good or Moderate or Risky or Avoidance or Don't Do it" appear at the top right of the model. In the case of **Business Strategic priority ranking**, investment priority will determine what percentage it constitute priority. If the investment complexity is such that in order to meet business strategic objectives, complexities are such that they will be just about 40%, investment is more likely to be executable and initial forecasted returns on revenues are realizable. It means that investment is "Good".

Contrary to that, if the investment complexity is such that it is 90%, it is obvious that "Don't do it"! This means that this project may present complexities that will make it difficult to realize returns due to schedule delays and cost overruns. The procedure will be the same for all other KPIs and the score aggregated into the bottom of each KPA. When all KPIs and KPAs are populated, the **result** will appear at the top right corner with the ranking whether investment is "Good or Moderate or Risk or Avoidance or Don't do it".

In formula 7.2.1, the Total % of Complexity Factor requires incorporation with other financial evaluations made. The assessment of power-infrastructure investment and construction alone without consideration of complexity factor is investment stupidity. The data presented in Chapter 6, Table 6.1 together with understanding calculations of ROIs, IRRs, PIs and NPV requires incorporation into investment decision. In the formula 7.2, the definition of total value of power asset are the development costs (Dc) added to the maintenance costs divided by the discount factor. The developmental costs are the costs including the design and asset construction. The maintenance costs are the cost related to the maintenance of the asset. Discount rate of these values requires understanding Cost Price Adjustment (CPA) ratios or depreciation factors accordingly. This will be divided by the cost of total power to be generated.

On completion of calculating NPV the final investment risk assessment can be through consideration of % Total Complexity factor. What if the NPV is high but the Total % of Complexity Factor is also presenting the risk. It should be noted that the Total % of Complexity Factor will not force any business to restraint on its strategic investments, but it presents an untapped potential of investment analysis.

7.4.3 The new model of discovering IRR

This was the model developed unintentional but on detail analysis, the study discovered that this model has not been developed and presented in journals. Articles related to Total % of Complexity Factor models can be available but there are not being discussed in relation to solving capital power-infrastructure investment. Although the models appear to provide the conceptual understanding, but there is a need to understand the related investment complexity and how to calculate IRR. In Chapter 6 Diagram 6.4 presented the scenario when IRR is between the two discount factors.

The calculation to determine IRR, where NPV will be zero, uses both trial and error and algebraic procedure or steps. This study went further to determine IRR where trails of discount factors are lower than required discount factor. The demonstration of this is in Diagram 6.7 and Diagram 6.8. In both these diagrams, determining IRR requires algebraic analysis and understanding. The details of the steps are narrated together with diagram 6.8 and they are the opposite of what was presented in diagram 6.2 calculations. These models are the key in the future of investment decisions and more particularly for long-term investments.

7.5 RECOMMENDATIONS

Globally, power utilities are described as operating like the roller coaster in terms of revenue income. The reasons leading to this include lack of upfront planning for long term planning. This study recommends the need for progressive disinvestment on the existing fleet of coal power plants due to reaching their life span and carbon emissions and recommends a more cautious approach of ensuring least cost on greener energy. This study reviewed Medupi, Kusile and Ingula and determined that in all power-infrastructures including for distribution and transmission divisions, lack of upfront planning is among reasons leading to cost overrun and schedule delays. It is recommended that unless Total % of Complexity Factor is considered, it will always be difficult for investors to determine if long-term power-infrastructure capital investment will yield benefits initial envisaged.

The study recommends that there should not be political interference in addressing revenue income deficit due to non-payment. In this study, it became eminent that debt cripples the economy in the same way as load power shortage or poorly maintained infrastructure that fails power frequently. The study further revealed that the shareholder contributes to some of the challenges due to indecisiveness. The study recommends that the shareholder has to be decisive early enough on the future of power utilities. This prepares knowledge management.

The study further recommends that there should developed assurance mechanism that BBEEE policy develops local business more particularly in terms of skills. The study recommends that investment

should not be treated differently that an understanding that “speed kills”. Therefore, those discharged with fiducial responsibilities should always be cautious of making decisions that are hasty. This means that investment committees should not be rushing to implement decisions without proper due diligence. The study recommends that investment decision need to be cautiously taken, with adequate upfront planning.

The study found that should government had explained earlier that the Eskom was going to build Medupi, Kusile and Ingula, and a skills retention program was going to ensure minimum emigration of skilled personnel. It was going to further assist in the development of knowledge base such as calculations and written by experienced engineers that were involved in the EPCM process of mothballed power stations. Therefore, this study recommends that in order for power utilities to grow their revenue income, they have to provide services internationally such as engaging in nuclear development opportunities in developing countries, providing construction services for power-infrastructure in under-developed economies. Further to that, power utilities can provide services to private businesses by advising industrial customers with energy experts. There are also great opportunities for manufacturing and selling power accessories such as transformers, and cables.

The study further recommends internal capacity development of engineers to an extent that power utilities will be able to develop their own equipment or products and sell them international. This will promote self-sustainability, reduce expenditure, and increase profitability. South African power utilities have engineers that are able to design power lines, run construction projects, development best policies and have better governance systems. These are some of the product offering that power utilities should be offering just like other international state companies such as Rosatom from Russia, Westinghouse from USA and other world known power utilities that are offering their service in the developing countries.

The study recommends the need to reduce government salary bill by ensuring that the vertical integration of power utilities does not compromise their autonomy to exercise due diligence towards self-sustainability. The study recommends that power utilities with the strong emphasis on municipalities, have to operate without political manipulation in order to generate their income, promote safety and ensure grid code compliance in terms of NERSA requirements. The study further recommends that in order for power utilities to meet growing demands they should drive the Integrated Development Plan (IDP) including power demand requirements by mines.

7.6 CONCLUSION

This chapter, on the onset presented detailed overview of South African power utilities and related capital power investments challenges. The chapter then presented the past reality versus the current reality faced by power utilities. The study presented the clear distinction that the past power utilities were prominent of having strong financial security compared to the current reality where power utilities are in liquidity crisis. This was through comparative analysis as presented in Table 7.1. Further to that, the chapter presented detailed answers to questions that were the objective of the study. In all questions, each question was answered with adequate details, taking into considerations current global and domestic political dynamics.

The chapter provided recommendations that developed through collaborative analysis of information from the literature review, data gathering from both qualitative and quantitative analysis and discussion that prevailed in Chapter 6. This collaborative analysis provided an overview understanding of capital power-infrastructure investment challenges. In this study, the chapter developed and presented three models. These models were clearly demonstrated how they work, their importance and were recommended for their incorporate application in investment market.

The first model was the application of Sectional Power Asset Undertaking, Distribute and Control, which was thoroughly in relieving government burden pressure. The second model was the application of algebra towards discovering IRR when NPV instead of a long trial and error method. The third model was incorporation of the complexity factor in investment development analysis. In these models, the chapter made clear presentation that financial models that are used are not adequate for investment decision making, as they assume ideal world or they have linear thinking when it comes to infrastructure development, which is diverse.

The overall study managed to present the overview of the challenges faced by power utilities. In May 2019 in South Africa, there was national government election. There was no political party ever mentioned on their manifesto that they wanted to ensure that consumers pay for electricity. This study therefore provided an alternative understanding with limitations of the Resource Integration Plan (IRP) waited for its publication since March 2019. This study will provide guidance towards consideration of how investors and power utilities should review their investment plans. The study concludes that the application of systems thinking was relevant to resolving these complex matters, as it was able to provide detailed analysis of the overall causalities including the IPPs, taxation, investment shortfall for developing countries.

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APPENDICES

APPENDIX B.1: THE LETTER OF INFORMED CONSENT

UNIVERSITY OF KWAZULU-NATAL
SCHOOL

Dear Respondent,

PhD Leadership Research Project
Researcher: Zothini N Chili (072 463 7218)
Supervisor: Dr Bonginkosi Zondi (074 412 7054)
Research Office: Ms P Ximba 031-2603587

I, **Zothini N. Chili,** PhD student, at the **Graduate School of Business,** of the University of Kwazulu Natal. You are invited to participate in a research project entitled: **Application of systems thinking in reviewing power infrastructure capital investment in South Africa**.

The aim of this study is to: The main aim of this study is to investigate how systems thinking can be applied in addressing deficiency of capital power infrastructure investment affecting economic growth in South Africa.In this, the study will review the application of existing financial models such as:

- ✓ Return on Investments (ROI), Internal Rate of Return (IRR),
- ✓ Schedule Performance Index (SPI) et cetera to multi-years capital investments with an intention of introducing new investment evaluation model

Through your participation I hope to understand how power utilities in both developing and developed countries manage to achieve returns on power infrastructure investments, and how they manage to handle delays due to stakeholders disagreements, as well as how they contain escalating investment costs. The results of the survey are intended to contribute to academic and power utilities knowledge.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business of UKZN.

In case you are, the respondent selected for personal or telephone interview such as Power Station Managers etc, the permission to do audio recording will be requested, the purpose of audio recording will be explained, which is to provide assistance after the interview by recalling the conversation, capture it properly and insurance of ethical compliance.

If you have any questions or concerns about completing the questionnaire or about participating in this study, you may contact me or my supervisor, at the numbers listed above.

The survey should take you about 15 minutes to complete. I hope you will take the time to complete this survey.

Sincerely

Investigator's signature_____ Date_____

This page is to be retained by participant

This page is to be retained by participant

UNIVERSITY OF KWAZULU-NATAL

SCHOOL

PhD Leadership Research Project

Researcher: Zothini N Chili (072 463 7218)

Supervisor: Dr Bonginkosi Zondi (074 412 7054)

Research Office: Ms. P Ximba 031-2603587

CONSENT

I……(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.
I understand that I am at liberty to withdraw from the project at any time, should I so desire. I am also aware and have granted permission for the researcher to do audio recording during the interview process.

SIGNATURE OF PARTICIPANT DATE

……

This page is to be retained by researcher

APPENDIX B.2: GATE KEEPERS' LETTER

Eskom

Professor M. Hoque
Academic Leader-Higher Degrees and Research
University of KwaZulu-Natal
Graduate School of Business and Leadership
WESTVILLE-CAMPUS

Date:
28 May 2018

Enquiries:
Tel +27 11 629 8076

Dear Professor M. Hoque

AUTHORITY TO CONDUCT DOCTORAL STUDIES RESEARCH: ZOTHINI CHILI 205522499

I have had discussions with Zothini Chili regarding his studies and I have given him the permission to conduct the research in line with the request of University of KwaZulu-Natal (UKZN).

The permission is related to reviewing capital power infrastructure investment using systems thinking. In this study, Eskom will be used as the case study. He mentioned to me that his study is not only limited to Eskom as it involves the global and national trend of other power utilities. It will also include municipalities.

The permission given is related to academic purpose only related to his studies and he is prohibited in using information that is confidential and unrelated information to his studies.

Yours sincerely

[redacted]

Name Surname
Nuala Jackson
Senior Manager: Eskom Enterprise

Date: 11/06/2018

Eskom Enterprise-Growth Office
Real Estate building
Eskom Megawatt Park
1 Maxwell Drive
Sunninghill, Sandton
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Eskom Holdings SOC Ltd Reg No 2002/015527/30

APPENDIX B.3: QUANTITATIVE RESEARCH INSTRUMENT

1. Scope is not adequately defined during concept phase that leads to variations during execution phase

●Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly Disagree

2. The cost basis does not fulfil entire capital power-infrastructure investment requirement

●Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly Disagree

3. Resource requirements for asset construction are not stipulated properly, this results in repetitive power outages and lose incentive when negotiating with regulator for tariff increase.

●Strongly Agree ●Agree ● Neutral ● Disagree ● Strongly Disagree

4. Stakeholders disagreements and power exercise is the major cause for leading to cost of completion uncertainty

●Strongly Agree ●Agree ● Neutral ● Disagree ● Strongly Disagree

5. Contracts used during procurement get manipulated by contractors to make more money without delivering asset.

●Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly Disagree

6. Diplomatic relations with neighbouring countries are among challenges that compromises power-utilities revenue's income deficit thus affect power-infrastructure investment.

●Strongly Agree ●Agree ● Neutral ●Disagree ● Strongly Disagree

7. Political alignment of municipalities with the ruling party contributes to power utilities' poor revenue income as it becomes difficult to disconnect consumers that are not paying for electricity services in order to secure votes.

●Strongly Agree ●Agree ● Neutral ●Disagree ● Strongly Disagree

8. The cross-border Power Purchasing Agreements (PPA) between South Africa and neighbouring have lost its value, as Eskom has never cut off power supply to any country or any local municipality.

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

9. The bilateral trading agreement is not explicit about what are the binding law enforcement avenues to recover payment from defaulting countries

●Strongly Agree ●Agree ●Neutral ● Disagree ● Strongly Disagree

10. Lack of in-depth understanding of foreign tax laws when providing or receiving services in foreign countries, are among reasons power utilities are losing revenue income

●

Strongly Agree ●Agree ●Neutral ● Disagree ● Strongly Disagree

11. Townships that are owing utilities billions of rand, such as Soweto should be switched to enforce payment, customers that are paying should be temporarily supplied with alternative supply such as batteries

●Strongly Agree ●Agree ● Neutral ●Disagree ● Strongly Disagree

12. Bypassed Large Power Users (LPUs) and Small Power Users (SPUs) should have their direct infrastructure removed and they should re-apply for reconnection when they are willing to pay timeously.

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

13. If politicians can always emphasize the need for electricity payment, utilities revenue income can improve

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

14. Private, Public Partnership (PPP) in power-infrastructure investment will ease government's constrained budget of infrastructure development and maintenance

●Strongly Agree ●Agree ● Neutral ●Disagree ● Strongly Disagree

15. Government Department that are providing essential services should be funded through fixed rate not linked through credit rating

●Strongly Agree ●Agree ● Neutral ● Disagree ● Strongly Disagree

16. Some of the Large Power Users (LPUs) such as mines, commercial, industries are among major contributors to power utility's poor revenue income as they bypass meters.

17. The fine amount that is paid after numerous years of non-payment is extremely small compared to what the consuming non-payer or meter temper would have paid on their monthly basis

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

18. The collusion of coal supplying mines to increase coal cost when selling to power utility results in tariff increases, consumers failing to pay thus power utilities revenue shortfall.

●Strongly Agree ●Agree ●Neutral ● Disagree ● Strongly Disagree

19. The additional costs required to fulfill stakeholders' expectations during project construction, could have been used in another project, should stakeholders had enlisted their expectations during conceptual stage

●Strongly Agree ●Agree ● Neutral ● Disagree ● Strongly Disagree

20. The performance of critical external stakeholders such as Department of Environmental affairs will be improved by deploying power utilities' resources to be housed within that department to speed up constraining permits

●Strongly Agree ●Agree ● Neutral ●Disagree ● Strongly Disagree

21. The project manager should compact stakeholders and do performance assessment (PA) during after the project is completed.

●Strongly Agree ●Agree ● Neutral ● Disagree ● Strongly Disagree

22. The trade union bargaining issues are the major causes affecting project cost and schedule leading to increased expenditure due to undertaking insurance.

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

23. The stakeholders' politics due to Expanded Public Works Program (EPWP) leads to project delays and cost overrun thus affecting another investment opportunity that could be pursued.

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

24. The ROI analysis done during the feasibility is not realized in most of the capital power-infrastructure projects.

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

25. The Internal Rate of Return (IRR) analysis done during the feasibility is not realized in most of the capital power-infrastructure projects

●Strongly Agree ●Agree ●Neutral ●Disagree ● Strongly Disagree

26. The initial forecasted Net Present Value (NPV), in most capital power-infrastructure investment is not realized

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

27. The viability of electrification and/or township infrastructure investments should include dedicated law enforcement resources

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

28. Ability to link credit rating, or with internet or cellular phone will help improve timeous payment.

●Strongly Agree ●Agree ● Neutral ● Disagree ●Strongly Disagree

29. The new financial evaluation model that will include the percentage risk of non-payment payment, investment recovery, time of investment is required

●Strongly Agree ●Agree ● Neutral ●Disagree ● Strongly Disagree

30. Procurement of goods and services from foreign countries is the major cause for the delay leading to Interest During Construction (IDC) to demand cost increases

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

31. The South African labor rights to strike delays freight system, increases transportation insurance and increases investment delay costs

●Strongly Agree ●Agree ●Neutral ●Disagree ● Strongly Disagree

32. The environment of operation including regulating laws such as Supplier Development and Localization (SD&L), Original Equipment Manufacturing (OEM), contractual agreements and local community expectations contribute to the delays in power-infrastructure investment and development

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

33. The contract signed between two parties get manipulated by the seller in order to take advantage of the power utility thus increasing the investment cost

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

34. The foreign companies to play supervisory role where their skills are required, the doers should be the local companies and intellectual properties including lessons learnt, procedure of commissioning should remain in South Africa

●Strongly Agree ●Agree ●Neutral ●Disagree ●Strongly Disagree

APPENDIX B.4: QUALITATIVE RESEARCH INSTRUMENT

- **What could be the challenges regarding development of capital power-infrastructure investments in South Africa?**

- **What impact would timeous payment by debtors have in capital power-infrastructure investments in South Africa?**

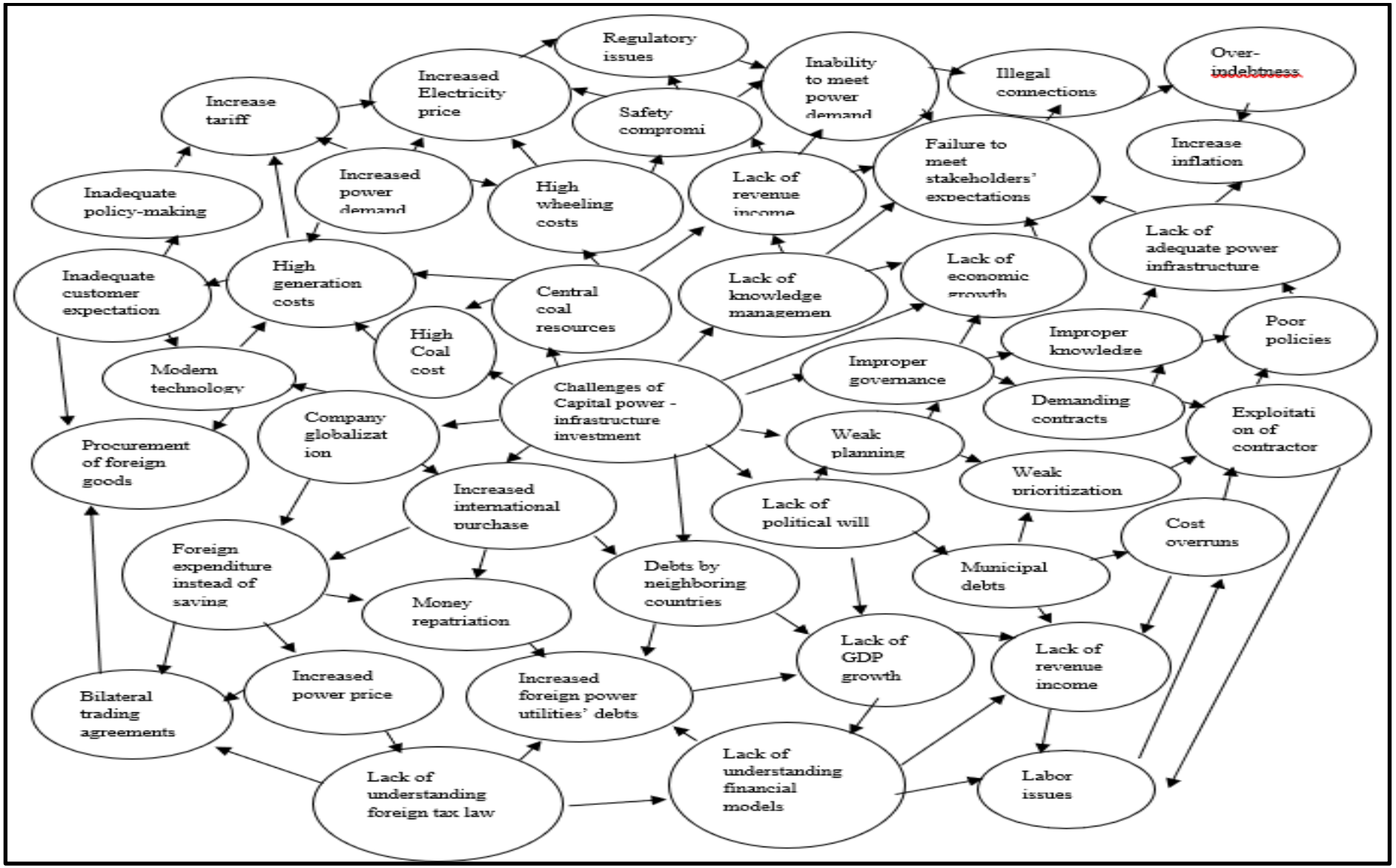
- **What would be the extent of investment opportunities lost due to costs escalations using stakeholder analysis?**

- **What could be the systemic model formulated to evaluate the long-term power-infrastructure investment in South Africa?**

- **What systems thinking could determine as an impact that the procurement of long-lead goods and contracting of foreign skills have on projects?**

APPENDIX B.5: SYSTEMS THINKING DRAFT PROCESS IN CAPITAL POWER-INFRASTRUCTURE INVESTMENTS

APPENDIX B.5: THE SYSTEMS THINKING DRAFT PROCESS



APPENDIX B.6: THE MODEL OF TOTAL % COMPLEXITY FACTOR

Total % of Investment Complexity factor

Investment Successful Assessment Criteria	INVESTMENT COMPLEXITY RANKING					RESULTS
	Good	Moderate	Risky	Avoidance	Don't Do it!	
	<40%	>50<60%	>61<80%	>81<90%	>91<100	

Internal organizational investment differences — Internal Stakeholders — **Weight:** 20

	Performance Indicators	Measurement	Source of Evidence	Weight	Good	Moderate	Risky	Avoidance	Don't Do it!	Actual Perf.	Score	Weighted Score
1	Business related strategic priority ranking	PERCENTAGE	Prioritization ranking report	20	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
2	Design delays related impact	PERCENTAGE	Design progress to meet due date	20	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
3	Possible scope change on execution	PERCENTAGE	Survey, engineers, tow n planners	20	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
4	Capital process budget approval delays	PERCENTAGE	Fund availabilty on WBS	20	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
5	Asset construction related complexities	PERCENTAGE	Permits, Memos, Draw ings etc	20	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
										Total		

External Stakeholders possible differences — External Stakeholders — **Weight:** 20

	Performance Indicators	Measurement	Source of Evidence	Weight	Good	Moderate	Risky	Avoidance	Don't Do it!	Actual Perf.	Score	Weighted Score
1	Most likely community complexities	PERCENTAGE	SAPS POP w rt violences, Protests	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
2	Municipality issues	PERCENTAGE	Municipality report	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
4	Contractors related possible labour disputes	PERCENTAGE	Possible payrate versus municipal	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
5	Government related possible delays	PERCENTAGE	Delays such as for IRP,NDP etc	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
										Total		

Political related complexity — Political Dynamics — **Weight:** 20

	Performance Indicators	Measurement	Source of Evidence	Weight	Good	Moderate	Risky	Avoidance	Don't Do it!	Actual Perf.	Score	Weighted Score
1	Dominance of one political party in the area	PERCENTAGE	Previous IEC reports	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
2	The history of political killings in the area	PERCENTAGE	SAPS	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
3	Previous promises made but not honored by senior politicians	PERCENTAGE	Interview s, IDP,SDP etc	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
4	Possibility of EPWP w ork become political	PERCENTAGE	History, IEC report	25	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
										Total		

Environmental Knowledge — On Site Discoveries — **Weight:** 20

	Performance Indicators	Measurement	Source of Evidence	Weight	Good	Moderate	Risky	Avoidance	Don't Do it!	Actual Perf.	Score	Weighted Score
1	Historical battles and possible graves not easily visible	PERCENTAGE	Engagement of local leaders	50	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
2	Protective trees, bush that requires construction attention	PERCENTAGE	Botanist, survey, interview s	20	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
3	The area topographical construction complexity, including access	PERCENTAGE	Difficulty factor rating	30	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
4					<40%	>50<60%	>61<80%	>81<90%	>91<100%			
5												
										Total		

Criminal nature of the area — Area Crime Nature Scanning — **Weight:** 20

	Performance Indicators	Measurement	Source of Evidence	Weight	Good	Moderate	Risky	Avoidance	Don't Do it!	Actual Perf.	Score	Weighted Score
1	Arm and knife robbery (Note that this is could lead to fatality	PERCENTAGE	SAPS, Interview s	50	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
2	The statistics of area vehicle hijack (This could lead to hijacking material delivery)	PERCENTAGE	SAPS, Interview s	30	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
3	House breaking or Industrial robbing (Note that criminals w ill break into you camp to)	PERCENTAGE	SAPS, Interview s	20	<40%	>50<60%	>61<80%	>81<90%	>91<100%			
4												
5												
										Total		

APPENDIX B.7: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

27 September 2018

Mr Zothini Nicholas Chili (205522499)
Graduate School of Business & Leadership
Westville Campus

Dear Mr Chili,

Protocol reference number: HSS/1174/018D
Project title: Application of systems thinking in reviewing power infrastructure capital investment in South Africa

Approval Notification – Expedited Application

In response to your application received 02 August 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....[redacted].....
Dr Rosemary Sibanda (Deputy Chair)

/ms

Cc Supervisor: Dr B Zondi
Cc Academic Leader Research: Professor Muhammad Hoque
Cc School Administrator: Ms Zarina Bullyraj

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