

# **An Energy Management plan for Centlec (SOC) Ltd in the Mangaung Metro (Bloemfontein)**

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**By**

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## DECLARATION

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# CHAPTER ONE: INTRODUCTION AND BACKGROUND

## 1.1 Introduction

A complex task, planning and implementing modern electric systems requires estimation of future power generation and consumption (Lannoye, Flynn, and O'Malley, 2012). Firstly, the electric system is made up of many interconnected circuits and machines. The task of maintaining acceptable voltages and frequencies in these systems under rapidly changing conditions is challenging in and of itself. Secondly, scheduling short run generation and load management to minimize costs can be challenging due to uncertainty in equipment and load availability, as well as the sheer number of alternative schedules that are possible. Last but not least, long-term planning requires sorting through the diverse range of possible resources and in-service times, while keeping in mind the implications for short-term schedules and costs (Loken, 2007). It is Eskom, as a power supplier, and Centlec, as a distribution and retail company, which is responsible for planning and implementing electricity generation and distribution in Mangaung metro municipality and broadly in South Africa.

In 1902, Centlec became the power utility for the city of Bloemfontein, with a capacity of 102 MW (Megawatt). It last operated in 2006 with a peak power demand of 60 MVA (Mega Volt Ampere). Centlec (SOC) Ltd is an exclusively owned subsidiary of Mangaung Metro Municipality. Centlec is also required to comply with the Municipal Finance Management Act (MFMA) of 2003, which is a part of the Municipal Systems Act of 2000 and Companies Act of 1973. Moreover, Centlec (SOC) Ltd accounts for 96% of domestic and residential electrical consumers in Bloemfontein. Another 4% of Bloemfontein's electrical consumption is consumed by commercial buildings such as malls, government buildings, offices, and other businesses (Centlec Annual Report 2010/2011- 2017/2018).

As part of the New York Global Energy awards ceremony, Eskom was named 2001 Power Company of the Year by the financial times. Nonetheless, because of corruption and mismanagement, Eskom became a liability to the state (Ward, 2020). In spite of having a capacity of over 45,000 MW, Eskom could generate only 27,000

MW and reverted to "rolling blackouts". Pravin Gordhan, Minister of Public Enterprises, observed in 2019 that Eskom was experiencing "systemic corruption, malfeasance, fraud, and state capture" that had "eroded investor confidence and compromised the credibility of the organization" (Ward, 2020). The failure of Eskom directly affects the power network provider and retailer which is Centlec.

Centlec currently only purchases electricity from Eskom and does not generate its own. Centlec has been forced to completely rely on Eskom because of this phenomenon (Inglesi-Lotz and Blignaut, 2011; Eskom, 2011a). On the other hand, Eskom produces its power from coal-based power plants. The National Research Council (2010) reports that coal (fossil fuel) and nuclear power (more recently), were the main energy sources used to expand industrialization, housing, and transportation over the 20th century. Despite this, the growing consumption of fossil fuels is resulting in higher electricity prices, depletion of coal, and carbon dioxide emissions to the atmosphere (Arent, Wise & Gelman, 2011).

South Africa's Integrated Resource Plan 2010 to 2030 (IRP) promulgated in May 2016 lays out the scale and mix of new electricity capacity needed over the next two decades for the first time. In addition to nearly doubling the system capacity, the new plan would drastically change the mix of energy sources and players in the marketplace. By 2030, coal's share of the energy mix will drop from 90% to 65%, renewables' share will increase to 9%, and nuclear's share will increase to 23% (Joffe, 2012). A third of the new capacity is to be built by private investors (Joffe, 2012). As a result of IRP (Integrated Resource Plan, 2010 to 2030), Centlec should formulate its own energy management plan to reduce its dependence on Eskom and become a leader in renewable energy generation.

It is projected that renewable energy resources will play a crucial role in the production of electricity in future energy systems. Ellabban, et al. (2014) argue that renewable electricity presents a significant opportunity for supplying domestically produced, low carbon dioxide (CO<sub>2</sub>) emitting power and resulting in economic opportunities. Despite this, the study is of paramount importance in terms of developing an energy management plan involving alternative energy production for Centlec in the near future.

## 1.2 Problem statement

In recent years, South Africa has been facing challenges regarding different stages of load shedding. The main attributes to these challenges are a growing demand of electricity, shortage of coal, resource mismanagement, corruption scandals and malfunction of the power stations due to aging. Furthermore, these challenges are forcing some business and households go off-grid, using mostly solar energy (Azimoh, Wallin, Klintonberg, and Karlsson, 2014).

Eskom as the main power producer, its shortcomings directly affect retailers and re-distributers such as Centlec. As a result of nonexistence of energy management planning, in particular the electricity industry miscarries to meet the demand of electricity. Thus, to reimagine and redesign Centlec's' energy management plan would be beneficial for future growth of the organization and to reduce or eliminate it's solely dependence on Eskom.

The need for developing the energy management plan emanated from Centlec' s full dependence on Eskom as well as the indication of the future energy production systems which Centlec has not envisioned yet. The question, however, what does the future of energy production entails? According to International panel for Climate Change IPCC (2018), currently used fossil fuel energy sources (like coal, oil/petroleum, and natural gas) are being replaced with sources emitting much less carbon dioxide (like wind, solar, and nuclear). Furthermore, the energy system must become carbon-neutral within the next few decades in order to prevent catastrophic climate change impacts (IPCC, 2018). By connecting consumers with the future broadly or with their future selves specifically, long-term decisions can be reoriented. Hence, the needs for energy management plan for Centlec.

In conclusion, the energy management plan comprises of assessing the current management system; current electric consumption and demand; strategies that include the future of power generation. Therefore, the research question would be, what is the current energy management plan for Centlec? What is the current energy consumption and demand? What are the alternative and sustainable energy generation means for Centlec? This research attempts to answer the aforementioned questions from which the energy management plan will be developed for Centlec.

## **1.3 Research Objectives**

### **1.3.1 Primary research objective**

The purpose of this study is to develop an energy management plan for Bloemfontein Centlec (SOC) Ltd as a way of reducing its dependence on Eskom and ensuring that its customers are supplied with energy on a consistent basis.

### **1.3.2 Secondary research objectives**

The secondary objectives of the study are to:

- Review the current energy management plan for Centlec
- Assessment of the Bloemfontein Centlec business plan for 2020-2023
- Alternative energy sources will be discussed in light of theoretical studies
- Utilize Centlec's database to identify and categorize sectors and areas based on energy consumption in Bloemfontein.
- Determine the causes of the increase in electricity demand in Bloemfontein, in order to gap the demand.

## **1.4 Preliminary Literature review**

Currently, there has been an increasing number of blackouts, otherwise known as load-shedding (Joffe, 2012). Eskom, with a capacity of over 45,000 MW, was only able to generate 27,000 MW, resulting in "rolling blackout" (Ward, 2020). For a while, corruption, mismanagement and other external factors made Eskom a spotlight story, a failing state-owned institution (Woode-Smith, 2019). Eskom's decline in productivity directly impacts entities such as Centlec, which procures and distributes electricity from Eskom.

According to Joffe (2012), an industry that is dominated by coal-fired power and by a single player - Eskom - needs to shift to more diverse sources of supply and a more

diverse player base. The implementation of a diverse energy mix is essential if this industry is to cope with the challenges of a shortage of demand, socioeconomic factors, and environmental factors.

New players will bring new funding, new technology, and new skills to the table. There is no doubt, however, that these transitions will take time and will need to be carefully managed. A major challenge for the electricity sector, and their policymakers, is to find a balance between these pertinent aspects of securing the supply of electricity now and in the future, making it more sustainable, all at a cost that is affordable for the country, and in turn, attracting the investment and infrastructure which will be necessary to exceed expectations.

As Joffe (2012) points out in the previous paragraphs, it is necessary to diversify key players, including Eskom, to generate more power and to replace coal as a source of electricity. This is where Centlec should step in. A Centlec Business Plan 2020-2023 warns that the energy landscape is undergoing rapid changes due to three trends disrupting the status quo. These include:

- Renewable energy technologies and energy efficiency services;
- Small, distributed generation and storage that are being deployed at larger scale; and
- Unprecedented growth and cost improvements in renewable energy sources.

In addition, Centlec's 2020-2023 Business Plan acknowledges that individuals and commercial entities are fast becoming competitors through off-grid solutions. Due to solar panels' increasing efficiency (Centlec, 2020), this trend is expected to continue. The trend is challenging the traditional way in which the network operates, posing a challenge to regulators, planners, utilities, and individuals alike. Even though these challenges can be viewed as threats, they also present many opportunities when planned and considered appropriately" (Centlec, 2020). Also in the Centlec report for 2019/2020, the energy consumption has decreased while the rand value has increased as a result of customers that implemented energy management, such as energy efficiency, load management, and alternative energy sources, in response to the higher electricity tariffs and constant load-shedding. That is where Centlec can benefit from this research by developing an energy management plan. The literature

review in Chapter two covers a more rigorous theoretical approach to alternative energy sources and their socioeconomic and environmental benefits.

## **1.5 Research Methodology**

In this section, the research methodology that will be employed is briefly described. However, the detail of the research method is outlined in chapter three, in the research methodology chapter.

### **1.5.1 Research design**

In this study, mixed research design will be employed. In order to address topics such as trustworthiness and reliability and validity, mixed methodologists use quality inference rather than either quantitative research or qualitative research. In addition, triangulation design model which is structured that both qualitative and quantitative data can be accommodated in different sections. The results of both methodologies will be presented in the same format. Then, a thorough discussion of both data results is presented under the neo conclusion heading. As a result, researchers adopting this type of design model present both their results from different methodologies as contradictory evidence for their results. A researcher could also try to conglomerate the results by converting one type of data into another in line with a particular methodology (Längler, Brouwer and Gruber, 2019). Therefore, this study justifies the use of triangulation model due to the nature of data that will be collect and the need to integrate the result from different perspectives.

Tanakakori and Teddlie (2009), have proposed strategies for reducing and/or addressing potential threats to inference quality. In their view, random assignment to groups, matching, homogeneous grouping, comparing individuals with themselves, statistical control, and double blind procedures all contribute to reducing and / or dealing with potential threats to the quality of quantitative inferences (Subedi, 2016).Therefore, mixed research design has an advantage over a singular use of either qualitative or quantitative approach.

## 1.5.2 Sampling Design and Technique

Population refers to the subject of the research or all units under investigation. This can include people, groups, organisations or products (Welman, et al., 2010; Ajibade, 2017). The target population of this study consists of key personnel from Centlec, external consultants and Centlec's customers. In this study key personnel implies the middle and upper managers of each section within the Centlec organisational structure.

### *Key personnel*

Figure 1.1 refers to sections of the Centlec organisational structure. In each section within the organisational structure, there are at least two middle management or higher positions, which the study will employ for the interviews. In total, 12 Centlec middle management and/or higher, will be interviewed on issues of the current energy management plan and its effectiveness; current strategies to supply the rising energy demand; and the need for alternative energy production due to the rising environmental concerns in the fossil fuel based power production. The sampling will include the office of CEO of Centlec, Human resource directors, head of finance, head of compliance and performance, head of engineering wires and head of engineering retail. Such sampling technique is known as purposive sampling technique. Purposive sampling ensures hand-picking subjects on the basis of specific characteristics and balances of group sizes when multiple groups are to be selected (Campbell et al., 2020).

### *External consultants*

The external consultants are mainly consists of experts in energy production management and those who are experts in environment and alternative energy. In total, 6 external consultants will be interviewed on issues similarly presented to key personnel. However, none of the external consultants will have any professional or personal ties with Centlec. Purposive sampling technique will be employed as it ensures hand-picking subjects based on specific characteristics.

## *Centlec Customers*

Lastly, 320 customers will be contacted for the survey data collection which is the quantitative aspect of the research. The sample size has been determined by making use of Raosoft online sampling software (Raosoft, 2022). The statistical workings of the Raosoft sampling as well as the number of interviewees from Centlec is explained in detail in chapter three. Stratified sampling technique will be employed for the survey. Stratified random sampling consists of dividing a population into smaller subgroups called strata. Stratified random sampling, or stratification, divides the sampled population into groups based on attributes or characteristics (Parsons, 2014). Therefore, the survey will be distributed randomly to businesses as they comprise the highest energy consumption.



Figure 1.1 Centlec organisational structure

**Source:** Centlec 2020, Organizational Structure

### **1.5.2.1 Data Collection**

Data sources can be broadly classified as primary and secondary data which entail firsthand and secondhand information, respectively (Johnston, 2017). The primary data will be collected from Centlec key personnel, external consultants as well as Centlec customers. The method of data collection from key personnel and external consultants will be via semi-structured interviews whereas from Centlec's customers through administering closed ended surveys. On the other hand, the secondary data will be collected from Centlec's annual reports, Centlec's database, scientific articles, journals, newsletters, books and reports.

Due to Covid-19, the interviews will be conducted telephonically, and the survey will be distributed via email to avoid physical contact.

### **1.5.2.2 Data analysis**

Data analysis plays a significant role in organizing and/or quantifying the data into defensible, actionable sets of conclusions and reports, thereby unleashing the potential to add in the knowledge pool. Data analysis depends on a set of techniques and methods that can be used to obtain information and to infer insights from the data (Rahman, M.S., 2020).

In this research, two data analysis techniques will be employed that encompass both the qualitative and quantitative data. The qualitative data will be analysed by making use of *thematic content analysis* whereas the quantitative data will be analysed by using SPSS (Statistical Package for Social Sciences)

### **1.5.3 Ethical considerations**

Ranthithi (2014) asserts that the cultural and moral values of a study population or certain group of people should be carefully considered by sponsors, researchers, students etc. in order to ensure collaboration with study subjects.

This study sought to gain the public's trust by promoting and respecting a variety of important moral and social values of the participants. The study promotes human rights, compliance with relevant laws, safety and human dignity by maintaining confidentiality. Additionally, the study will make sure that the necessary approval will be granted by the University of the Free State. Furthermore, permission from all the participating personnel and Centlec will be obtained. All participants will be informed about the objective of the study the anonymity of their responses. When completed, the research outcome will be communicated to the Centlec and stockholders.

## **1.6 Conclusion**

This chapter outlines the general overview of the research and the rationale for the study. Subsequently, the chapter explains the background of the study and the problem statement. Finally, this chapter describes the research objectives and the methodology along with the motivation thereof.

## **1.7 Chapters Outline**

Chapter 1 (Introduction) provides the background of the research, the research problem, the purpose and objectives of the study, as well as a summary of the research methodology to be employed.

Chapters 2 (Literature reviews) reviews the relevant literature pertaining to the study.

Chapter 3 (Research methodology) provides the overall plan of the research methodology by describing the research design, data collection and data analysis procedures.

Chapter 4 (Data collection and analysis) presents the data gathered and processed to show the findings according to the objectives of the study.

Chapter 5 (Conclusion and recommendations) provides a summary of the research and recommendations for future research.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Introduction**

Energy plays a critical role in economic development and social well-being in all countries (Li, Shen, Wei and Zhang, 2021). Energy is a special topic since it influences so many other consumption and production processes. As a result, energy is a crucial factor that determines many aspects of human activities in general.

Economic growth in developing countries in the last decade has caused a rapid increase in energy consumption. Kaygusuz and Bilgen predict that this trend will continue in the near future (Tukker, Charter, Vezzoli, Sto and Andersen, 2017).

Energy is one of life's most vital resources. As energy consumption increases, life styles improve (Letschert and McNeil, 2019). Consumption is critical to achieving sustainability. Global environmental degradation is largely attributed to unsustainable consumption, including overexploitation of renewable resources and pollution caused by fossil fuels. Increasing consumption is a key lever for achieving more sustainable development. However, global environmental degradation is largely due to unsustainable consumption, including overexploitation of renewable resources and pollution from fossil fuels (Zheng and Walsh, 2019). As a result, there has been a global movement in changing the patters and technology use of fossil fuel-based power production.

Combustion converts coal into useful heat energy, but it is also part of the process that causes the greatest environmental and health concerns. Combustion of coal at

thermal power plants emits mainly carbon dioxide (CO<sub>2</sub>), sulphur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), CFCs (Mittal *et al.*, 2012), other trace gases and air borne inorganic particulates, such as fly ash and suspended particulate matter (SPM). CO<sub>2</sub>, NO<sub>x</sub> and CFCs are greenhouse gases (GHGs). CO<sub>2</sub> produced in combustion is perhaps not strictly a pollutant (being a natural product of all combustion), nonetheless it is of great concern in view of its impact on global warming. Carbon dioxide is a stable molecule with less than ten years average residence time, i.e. three years in the troposphere (Raghuvanshi *et al.*, 2006), though its residence time is over 100 years in the atmosphere, and its present concentration in the atmosphere is increasing at an astonishing rate of 0.4% per year. The average residence time in the troposphere means the number of years a molecule exists before it is reused by another biological process on the earth's surface or broken apart in the stratosphere. Electricity has been a preferred form for energy consumption and has consistently registered a higher growth rate than other forms of energy.

## **2.2. Electrification in Africa**

The African power industry is characterised by small systems, with over three quarters of the electricity produced in Africa coming from South Africa and North Africa with developments in East Africa such as Ethiopia (Karekezi, Kimani, Mutiga & Ameny, 2003). The electricity industry in most of the sub-Saharan African countries is dominated by small systems, with heavy reliance on hydro power generation. The bulk of the electricity produced in Africa is from thermal stations, because of the large coal plants in South Africa and oil-fired generation units of Nigeria and North Africa (Karekezi, Kimani, Mutiga & Ameny, 2003).

According to South Africa's Ministry of Energy (2012), the total domestic electricity generation capacity is 51,309 megawatts (MW) from all sources, among which approximately 91.2%, or 46,776 MW, comes from thermal power stations (coal combustions), while 4,533 MW, or 8.8%, is generated from renewable energy sources. Conventional thermal power sources will most likely be the dominant source of electricity generation for the foreseeable future, but its share of total capacity is likely

to decrease as more renewable generation comes online in the coming years, which further indicates reliance on coal is not sustainable. South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) for utility-scale transactions signed 27 power purchase agreements in June 2018 and plans to add 19,400 MW of new renewable generation by 2030 according to the draft updated Integrated Resource Plan (IRP) released in August 2018.

### **2.3. Historical background of electrification in SA**

Up to the end of the nineteenth century the generators of all steam stations in South Africa were driven by reciprocating piston engines. Overseas, the steam turbine was at that time proving itself far more suitable for electrical power generation. It was much more compact and the steam consumption was less. The higher speed was also a big advantage. At about the same time, there were some engineers who were convinced that the end of the steam age had arrived and that gas engines would be the prime movers of the future. It was said that a gas plant was simpler than steam and required less skilled labour. Little more than half the coal was required and less than half the amount of water of a steam plant. In 1904 the Johannesburg Town Council placed orders for three gas engines of 1000 hp each and five of 2000 hp. These sets proved to be a costly disaster and the whole of the plant were rejected in 1908. Steam turbines were installed instead (Eskom, 2019).

The first steam turbo-generator in South Africa was a Parsons 50 kW set installed by the Cape Peninsula Lighting Corporation at the Wynberg Central Station, Cape Town, in 1901. The building still exists in Electric Road and converted into apartments in 2006. Three 135 kW Parsons turbo-generators were installed by the same company at the Claremont Central Station in 1903, and the 50 kW set from Wynberg was transferred there as well (Eskom, 2019)

The De Beers Consolidated Mines at Kimberley commissioned the first large turbogenerator of 1 MW capacity in August 1903. A 200-kW set was installed at the

Porges Randfontein Gold Mine and a 500-kW turbine at the Driehoek Power Station in 1904. The Rand Central Electric Works installed a 400-kW turbogenerator in 1905. Larger sets soon followed, including 6 MW sets installed by the Randfontein Estates Mines and 9,6 MW sets installed by the Victoria Falls and Transvaal Power Co at Rosherville and 11 MW sets at Simmerpan (Eskom, 2019).

Between 1970 and the early 2000s, South Africa enjoyed a long period of plentiful electricity supply at some of the lowest prices in the world. This situation changed dramatically in June 2006 as the country's growing economy began to make full use of the electricity generation capacity that had been built in the 1970s and 1980s. This led to shortages of electricity and load shedding as the country was not able to generate enough electricity to meet demand, while preventing a collapse of the transmission system.

#### **2.4. Attributes of Electricity Production**

In 1994, when the newly elected democratic government took power, the electricity price was still cheap as a result of restricted electricity distribution imposed by the previous regime and the abundance of coal that was used as the primary energy source to generate electricity (Lalk, 2015). The base load power stations of Eskom were and still are coal fired power stations. It is still not easy to make a transition to the alternative (renewables) energy sources due to the higher costs to generate energy and high technical requirements. Furthermore, Lalk (2015) confirms that though the country has some hydro-electrical power resources, they have not been used in expansion.

Other than the Eskom power utility in South Africa, some of the municipalities had their own power stations/plants until 2006, which were mainly coal fired power stations. The reason behind owning the power stations was due to the abundance and availability of coal and reduced cost of transportation of coal. Some of the Eskom power stations were built not so close to the coal mines, and therefore they were also part of the coal supply and transportation program of Transnet. Like most of the municipal electrical

redistributors, Centlec also had its own power stations. During middle 2006 Centlec was requested to shut down their power stations and as a result offered to purchase the electricity at lower rates from Eskom.

In the beginning of 2007, the reality kicked in that the electrical energy supply was not sufficient to meet the demands of the country. Since 2007, the country suffered unplanned electric outages which marked the beginning to look for alternative energy sources. Lalk (2015) indicated that it was a creation of what one could argue was the “perfect energy storm” and during 2008 the country suffered rolling blackouts, referred to as load shedding. Large companies and the mining industry suffered most from these blackouts and thus resulted in economic fallouts. As a result of load shedding the Gross Domestic Product (GDP) of the South African economy has dropped from 5.6% in 2006% to 5.4% in 2007 and 3.6% in 2008, according to the STATSSA report of 2012

New energy policies were created such as Energy Efficiency Demand Side Management (EEDSM), the Industrial Policy Action Plan (IPAP), Integrated Resource Plan 2010 (IRP) and other policies, which were to emphasize the energy plan for the country. The economy of South Africa, which was driven by what was known as “coal energy” was now needed to be driven by an energy mix, including renewable resources such as solar, wind, hydro to name the few applicable to the country. This was to be known as renewable energy (Winkler, 2007).

Eskom’s energy generation was regarded as the main contributor to GHG (Green House Gas) emission with approximately 95% of South Africa and for Africa as a continent at about 45% (Greenhouse Gas Inventory SA, 2009). With the number of frequent outages together with the increased pressure to considerably reduce the Green House Gas (GHG) release, it has led Eskom and the government to reconsider new strategies towards a secure energy industry, and lead to diversifying the energy landscape of South Africa in the future.

In December 2010, during the Conference of Parties (COP) 17 meeting in the South African government committed itself to reduce the country’s GHG release by 34% and 42% by 2025. Eskom as main supplier of electrical energy in the country, established

the Integrated Demand Management (IDM) to respond on the said commitment of the South African government. Eskom's Sustainable Development Climate Change COP 17 studies (2016) indicate that the power utility contributes a significant amount of GHG due to electricity generation, and therefore they came up with six strategies to minimize these emissions and support the climate change drive. The first step was the diversification of the energy mix for electricity generation. Eskom generates electricity with 90% from fossil fuel sources such as coal and gas; and 10% with renewable sources such as hydro, wind and nuclear (Nel and Joel, 2019).

While in commencement of diversifying the energy generation mix, Eskom embarked on the short to medium term on off-grid initiatives such as Solar Water Heater (SWH) and a Compact Fluorescent Light (CFL) mass rollout to reduce energy usage and at the same time to reduce the GHG emissions. Other initiatives that support energy diversification are carbon capture storage on the new built coal fired power station and CO<sub>2</sub> mineralisation (Coal gasification). The retrofit on energy efficiency technologies such as lighting, Heating Ventilation and Air-conditioning (HVAC) systems, motion sensors and hot water were done in Eskom properties. External rebate programs of High-Pressure Solar Water Heaters (HPSWH) for Higher and Middle Living Standard Measures (LSM) and a mass rollout of EE lighting to all households were made available together with Low Pressure Solar Water Heaters (LPSWH) to Lower LSMs. All the projects were classified as Clean Development Mechanism (CDM) projects, which were mainly for GHG emission reduction. The third step of energy mix initiative is the Internal Energy Efficiency (IEE) measures which focus on an environmental control effect on the coal fired power stations operations. In particular, the emission control of the coal fired power stations, the water management and the air quality around the areas close to the coal fired power stations. The fourth step is innovation through Research and Development (R&D) and the aim for the initiative is to concentrate on waste management, e.g. ash of coal fired power stations, underground coal gasification, which is the process of CO<sub>2</sub> mineralisation, utility load management by using smart grid applications and power plan efficiency. The fifth step focuses on financing the opportunities for trading in the global carbon market. This project should be classified as a Clean Development Mechanisms (CDM) project that must contribute towards emission alleviation, e.g. Energy Efficiency Technology projects and renewable energy projects. Lastly, advocating partnerships, which are key to Eskom's

climate change strategy with all their stakeholders in attaining the mission and objectives of sustainability and development. One of the initiatives under the partnership of Eskom and South African government was 49 M (49 million population size of South Africa) program, which encourages electricity all the consumers to use electrical energy safely and efficiently (The Eskom Factor 2013).

Rifkin (2011) developed a five-pillar plan for the 27 European Union member states that intricate how and why the lateral power influences the modern world, the economy and the energy. The first pillar was the increase of renewable energy with 20% by 2020, adding to the existing renewable energy generation; therefore, the additional capacity of renewable energy will be up to a third of the total energy generated on the European continent. The second pillar was to determine how the renewable energy will be enhanced in the national grid. The analysis was done in order to determine the potential of renewable energy across the countries on the European continent. For example, Spain, Italy and Greece have a potential of solar energy; Ireland has potential of wind energy and Norway has a potential of hydro energy. Therefore, the electricity generated through the means of sources mentioned above will be integrated in the electrical grid and distributed across the continent of Europe with high voltage power lines. The third pillar is the storage of electrical power generated through renewable resources. Based on the fact that the source of these energies are intermittent, for example Europe has less solar irradiation, wind blows mostly at night in Ireland and due to the induced drought, the water table is low as a result of climate change. The fourth pillar was how the renewable energy generated is shared within the European continent by using the IT smart grid technique to transform the power grid into energy internet, for example when millions of buildings collect distributed renewable energy, the surplus can be shared with others by selling it back to the grid so that it can be available for other consumers. The last pillar addresses the transport industry in the Europe continent. The first 27 European countries participated in the renewable energy program integrated their transport industries by equipping their buildings with plugs in electric fuel cells to power up the vehicles.

In South Africa, the city of EThekweni Metro according to Morgan et al. (2013:56-61), has initiated a move towards alternative or renewable alternative electrical energy sources. The Ethekeeni Metro has developed a framework that will guide the

municipality Ethekewini Metro Municipality in terms of the implementation of the renewable energy strategies. This is one of the municipalities in South Africa which took the initiative to embark on an energy management plan. However, Moonsamy (2013:67-72) argues that renewable power generation sourced from water, wind or solar etc. have no regular amount of power production. Similar to Rifkin (2011) with the second and third pillars of plan for the European countries, indicated that electric power generated through the renewable resources are intermittent due to natural variation. Therefore, the embedded energy generation options in South Africa are the focus of users of electricity to improve energy savings and increase revenues derived from the sale of electricity.

Davidson et al. (2006) indicate that energy production has been one of the main contributing factors to the social and economic development of South Africa. They emphasize that energy generation has lent prosperity and security to the country by providing heat and power for industry, transportation, and household use. The sector has been largely driven by economic and political forces, which have had a profound impact on energy policies.

## **2.5 Energy Demand and the Environmental Conundrum**

According to the National Treasury report of electricity (2011):

“Electricity provision involves three phases: generation, transmission and distribution. Generation is the process by which electricity is produced; transmission is the transportation of electricity that has been generated in power stations via high voltage, long distance power lines to local networks for distribution; and distribution is the actual delivery of electricity to end users or consumers.”

Electricity generation and transmission together constitute electricity supply and in South Africa this is largely the function of Eskom (in some cases, municipalities have their own generation capacity, but on a limited scale). The distribution function is shared between municipalities and Eskom. Centlec Ltd purchases the bulk of electricity from Eskom and redistribute to its consumers. The current contract between

the two entities includes two 400 Mega Volt Ampere (MVA) transformers at a Notified Maximum Demand (NMD) of 326 MVA. Below is the 2018/19 Load Profile of Centlec-Parkwest substation, which supplies the City of Bloemfontein.

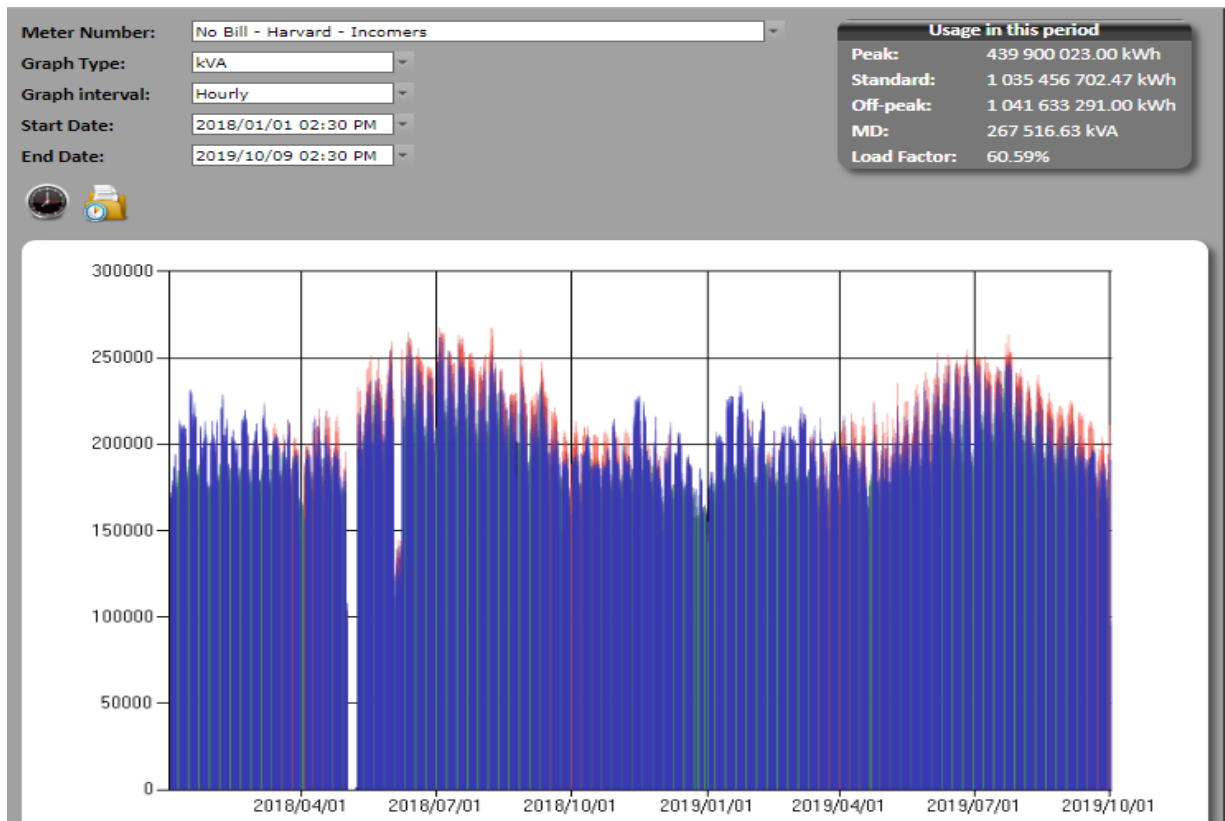


Figure 2.1 Load Profile of Parkwest Substation (2018 -2019)

**Source: Centlec Automated Meter Reading (AMR) system Load profiles (2019)**

As the South African economy begins to recover demand for electricity have also increased, placing strain on the country’s ability to generate enough power to meet demand. The ability to avoid load shedding over the coming years have depended on both the success of efforts to limit demand through increased energy efficiency and the timing of the completion of new and refurbished electricity generation capacity, and the pace and nature of economic growth. The energy consumed during 2018 and 2019 amounted to 2.452 8 GWh’s (Giga Watt hours) as per the above energy profile. Figure 2.1 shows that from the beginning of 2018 the demand of electricity still in a rise as it shifts to 2019.

Table 2.1: Environmental Impact of emission due to energy consumed

Item	/Kwh	Kwh's	Total / Year
<i>Litres Water Used</i>	1.4	2 452 800 000	3 433 920 000
<i>Kg. Coal Used</i>	0.53	2 452 800 000	1 299 984 000
<i>Ash Produced / Gram</i>	155	2 452 800 000	380 184 000 000
<i>SO<sub>2</sub> in Grams</i>	7.75	2 452 800 000	19 009 200 000
<i>NO<sub>x</sub> in Grams</i>	4.18	2 452 800 000.00	10 252 704 000
<i>CO<sub>2</sub> in Kg.</i>	0.99	2 452 800 000.00	2 428 272 000

**Source: Factors- Eskom Annual Report (2011)**

South Africa is one of the highest emitters of greenhouse gases according to the studies conducted by the National Aeronautics and Space Administration (NASA) between 1980 and 2015 (Carbon Brief, 2018).

As compared to other cities in Europe which fully exploit the opportunities of Green energy, Centlec and the City of Mangaung are in a perfect environment due to availability of solar irradiation to make use of PV as an alternative electrical energy source to power up the city of Bloemfontein and Mangaung Metro.

## 2.6 The Concept of Sustainability

In 1987, the Brundtland report of "Our Common Future" (WCED, 1987), have introduced the concept of sustainable development. The notion of sustainability caught

on since the late 1980s and became the concept that has been at the centre of both the natural environmental sciences and a wide range of environmental sub-disciplines in psychology, sociology, economics, law, and philosophy etc. (Robinson, 2004). Therefore, it is fair to assume that the basis for sustainability is the combination of several disciplines and sub-disciplines.

A new field of sustainability science is emerging that seeks to understand the fundamental character of interactions between nature and society. Such an understanding must encompass the interaction of global processes with the ecological and social characteristics of particular places and sectors (Kates *et al.*, 2001). It will also require fundamental advances to enable to address such issues as the behaviour of complex self-organizing systems as well as the responses, some irreversible, of the nature-society system to multiple and interacting stresses. Combining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information.

## **2.7 Renewable Energy and Sustainability**

According to Jain, Shilpi and Jain (2017), to deal with the energy crisis facing inaccessibility of electricity to the rural and remote area dwellers, and the problem of environmental degradation from over dependence on coal, South Africa adopted enabling policy frameworks to increase the share of renewable energy in the national energy mix which has been stated in the Integrated Development Plan (IDP) of 2018-2019. The feasible resources of renewable energy in South Africa are solar, wind, biomass, geothermal, hydropower, waste to energy, and the tidal (wave) energy. Their potential varies from one province to another. With the exception of KwaZulu-Natal and the Mpumalanga provinces which have the highest potential for biomass, the other seven provinces have the highest potential for solar energy (Jain, Shilpi & Jain, 2017). Wind has the second highest potential in the three Cape provinces, biomass has the second highest potential in the Limpopo province, and hydro has the second highest potential in the Free State (Department of Energy, 2015). The Government's commitment to promoting RE technologies goes back to post-apartheid 1996-Constitution of the country from which a number of policy documents have emerged,

namely the 1998 White Paper on Energy Policy (WPEP), 2003 White Paper on Renewable Energy (WPRE), 2011 White Paper on National Climate Change Response Policy (WPNCCR). The 2011 National Development Plan (NDP 2011) also reflects Government's commitment to RE technologies for sustainable development (Department of Energy, 2015). As a percentage of GDP, South Africa was the fourth largest investor in renewable power in the world in 2012. In 2012, 16.9% of total energy consumed came from renewables, which was mostly from the combustion of traditional biofuels for heating and cooking. In 2009, the National Energy Regulator of South Africa (NERSA) announced renewable energy feed-in-tariffs (REFIT), differentiated by technology for private producers to inject electricity in the national grid. The feed-in-tariffs were replaced by a competitive bidding process in 2011 comprising of two phases, the Qualification phase and Evaluation phase. The total allocation of RE generation capacity to over 92 power producers by the Renewable Energy Independent Power Producers Procurement Program (REIPPPP) in five rounds of the bidding process up to 2014 was 6,300MW, mainly from wind and solar generation (Sager, 2014). Total 1860 MW RE generation capacity had commenced with commercial operation by mid-2015 in South Africa (Department of Energy, 2015).

Environmental impacts are an inherent part of electricity production and energy use. Electricity generated from renewable energy sources has a smaller environmental footprint than power from fossil-fuel sources, which is arguably the major impetus for moving away from fossil fuels to renewables. However, although the types and magnitude of environmental effects differ substantially from fossil-fuel sources and from one renewable source to another, using renewables does not avoid impacts entirely. An understanding of the relative environmental impacts of the various electric power sources is essential to the development of sound energy policy.

## **2.7. Economical Aspect of Renewables**

In the previous section, the availability of renewable energy sources is identified by province. However, this section explores the economic aspects of renewable energy implementations further.

Profitability is the central core of economics. However, according to the American Solar Energy Society (ASES) (2007), the following three economic drives have to be achieved in order to attain profit, namely (1) the market price or value of renewable electricity; (2) the costs of renewable energy production compared to other sources; and (3) policies to promote renewables and environmental goals (particularly climate and energy security policies) that raise costs of using fossil fuels and/or subsidize costs of renewables.

Attempting to predict the future economic benefit of the renewable energy production is slightly complicated; given the monetary and technological implementation it requires (Vajjhala et al., 2008). Furthermore, many scholars argue that production of renewable energy is more costly than fossil fuel. However, most of these studies are done on small scale such as businesses and house rooftops, which lack the overview of large scale systems. Furthermore, these studies did not include operating maintenance cost of fuel energy production. Finally, ASES (2007) compared cost involved in producing energy by the renewables vs fuel sources and concluded with the following: (1) the difference of the initial cost involved in producing either from renewable resources or fuel is significantly small 2) in the long run renewable energy will be able to reduce the retail of electricity and (3) measurable environmental profit can be achieved.

## **2.9. Concept of Public Service**

Service delivery is a marketing concept that refers to the interaction between consumers and providers. Unlike physical products, services are intangible.

These characteristics are key factors that determine the viability of various forms of services. The ability to self-regulate, perishability, and inseparability are also important factors that affect the operation of various forms of services (Siyonzana, 2016).

The concerns of service delivery professionals include quality of service, impact on the customer, and satisfaction. The term public services have been used to refer to the delivery of services by public agencies or private organizations.

Services that are contracted by public agencies will remain within the scope of public services and are subject to the same public service criteria. Services that are contracted will remain within the scope of public services and are funded by the public purse.

According to Mpofu and Hlatywayo (2015), service delivery refers to the effective delivery of basic services to the citizens of municipalities or local governments. In a study by Chen et al. (2013) service delivery was described as “a common phrase in South Africa used to describe the distribution of basic resources citizens depend on like water, electricity, sanitation infrastructure, land, and housing.

## **2.10 Challenges to service delivery**

The public sector is confronted with various challenges such as the increasing complexity of public needs and demographics, the changing nature of public service delivery, and the increasing level of corruption (Bangura & Larbi, 2010). A major challenge to effective and quality service delivery especially in sub-Saharan Africa is what is termed political market imperfection, a phrase coined by Keefer and Khemani (2005) all form of flaws apparent in the relationship between the political class and the citizenry. This includes the non-fulfilment of campaign promises, the mismanagement of state funds, and the lack of information about the performance of elected officials. This leads to identity-based voting (Keefer & Khemani, 2005).

The failure to deliver on electoral promises often elicits various responses from the public. In South Africa, for instance, the widespread protests following the failure to deliver on promises have become known as the ubiquitous service delivery protests (Keefer, 2008). In Malawi, for example (and also in many other African countries) state resources are grossly used for political party ends (Keefer & Khemani, 2005). Thus location or implementation of projects are defined by presence or domination of party loyalists' resources for party political ends and this is very evident in the modality of

water provision in the country (Booth et al., 2006). Similar examples can be found in how health facilities were being situated in Niger (Olivier de Sardan et al., 2010).

It has been noted that many people living in informal settlements in rural South Africa are often overlooked when it comes to accessing basic services such as water. This is because they live in areas where the supply of water is limited (Chen et al., 2013)

Policies contradictions or incoherence has been identified as another bane of public service delivery. Such contradictions which could be traced to the size and usually unappreciated interconnectedness of the public section contradictions often occur both inter and intra sectors. They include contradictions in structure and policy designs and sometimes and roles. These could render part or an entire policy design to become implementable or unimplemented.

While the policies contradiction may often stem from poor coordination, it also takes practical manifestations which include overlapping mandates and mixed-up responsibilities among co-providers and other public entities (Wild et al., 2012). And sometimes it could take more fundamental forms like lack or inadequate implementation plans or funding plan (Booth, 2011).

Examples of how horizontal incoherence can result in confused responsibilities for service provision abound. A notable one is the observed form of incoherence (vertical) in Cameroon's health sector, where alignment of existing district and territorial administrative boundaries was not adequately taken into consideration in the course of implementing a process of decentralisation thus resulting into a totally chaotic situation characterised by burred supervision lines and unrealistic administrative expectations on some of the health districts (Gruénais et al., 2008).

Similar situation was reported in Kenya water sector where improper coordination interacted with existing unstructured political market to create a situation where programmes were drawn up and structures were created to run them but the prevailing situation as described created room rent seeking behaviours and inordinate scramble for resources (Rampa, 2011). The Kenyan experience was a case of total institutional weakness and lack of accountability. Despite huge investment into the water sector, the service delivery impact remains considerably low and the subsisting scarcity remained unabated (Rampa, 2011).

Such vertical coherence and attendant implementation gaps more often than increases cost and create room for room for funds diversion. Poor planning and vertical incoherence in Malawi education sector brought about a situation where parents still need to outlay school fees despite huge donor funds that were made available to the sector (Kadzamira & Rose, 2001).

It has been noted that such incoherence can be combated by initiatives that better define mandates horizontally and vertically for government and clarify roles and responsibilities; and strategies aimed at evolving stronger and more robust political leadership, as well as building capacity to drive delivery (Blair, 2010). Impacts of such strategies are evident in countries like Rwandan health sector which flourished under the dyad of Kagame's strong leadership and public engagement (Chambers & Golooba-Mutebi, 2012).

Weak and unstructured performance monitoring and oversight constitute another challenge to public service delivery. Service delivery will be grossly affected in places or situations where there is no formal supervision processes in place or where they are not being enforced or followed thus resulting in reliance on informal supervision which is seldom sufficient (Wild et al., 2012). This becomes worse in situations where there no clear enabling regulations for monitoring service delivery performance or characterised by low level of adherence. Such situation makes service delivery more difficult even in situations where non-state providers attempts to step in (Palmer, 2006).

The appalling thing is that even in situation where people take recourse to other providers because of lack of performance by public providers, such exit does not spur reforms but rather things get worse (Ayee & Crook, 2003). Sanitation situation in Ghana provides a case in point. Contracts for provision of public toilets went to politicians whose saw such contracts as mere tools of revenue generation hence they fail to perform, and the waste management department could not sanction them because of their political statuses (Ayee & Crook, 2003).

Poor service delivery due to of regulatory lapses is not limited to public providers alone. It has been noted that it is common place for private providers not to adhere to government regulations in some instances and thus resulting in sub-optimal delivery or practices as was observed in India and Liberia private health providers (Batley &

Mcloughlin, 2010). One notable cause of these performance monitoring and regulatory breakdowns besides from the political influence is when governments undertake reforms and changes without making similar reform and changes in the existing monitoring and regulatory framework. For example, many governments undertake decentralisation of 23 existing structures thus leading to expansion without making adequate provision for performance monitoring to cater for such expansion (Forsberg, 2011).

Thus, conclusively when performance monitoring is largely bottom-up i.e. by the users and communities instead of top-down (from formal monitoring agency) or a combination of both what happens is that service delivery continues to degenerate as the first reaction by users is usually to seek for alternatives which in some cases could be private providers operating at somewhat low standards as well especially in situations where cost is an issue and this has manifested itself in form of poorly organised private health facilities and other services in many places (Leonard, 2002; Batley & Mcloughlin, 2010).

Central to the provision of effective and quality public service delivery is the collective sense of responsibilities by all relevant actors. Moreover, significant here is the collective adherence by users to act responsibly in using provided facilities as well as in payment of tariffs where applicable. Not doing this often by a segment of actors often ultimately work to deprive everybody of the expected benefits (Olivier de Sardan et al., 2010).

“In some cases, institutional arrangements intended to solve some of the collective action challenges necessary to support service delivery have been present but have failed to function as planned. In Freetown, cost recovery within the water sector and improvements in quality and coverage of services depend in part on collective adherence to payment of water tariffs, and payment for water by any single service user is insufficient without that of other users (Harris et al., 2012). However, features of the underlying political economy have meant no collective adherence to tariffs; instead, a significant number of service users remain immune from sanctions for non-payment in Freetown”.

Looking at different cases and situations indicated that, the availability of alternative revenue sources like NGOs and donor agencies sources does not only drive the

moral hazards earlier mentioned within public service (Palmer, 2006), but could have more particularly problematic effects on service delivery where such external sources of funding are provided without due consultation with state authorities, thus leading to emergence of parallel systems and leading to provision with little oversight or regulation. This can further reduce the likelihood of transiting such alternative system 24 to sustainable forms of provision over the medium to long term as usually envisaged by such system. In Niger, for example, water boreholes have been provided almost exclusively by NGOs, with little consultation with local authorities. As a result, local authorities have been unable to map existing provision effectively, reducing their ability to plan for improved provision (Olivier de Sardan, 2010).

A study found that most of the facilities provided by NGOs to local leaders ended up being appropriated by local elites because they are usually unwittingly provided. This has contributed to an inefficient allocation of resources and, over time, inequitable access to such facilities (Harris et al., 2012).

South Africa's electricity power generation monopoly and the subsequent entities have had a fair share of challenges over the past decade (The Economist, 2015). According to the Staff Reporter (2012) South Africa faces serious crisis which could lead to load shedding throughout most towns and cities negatively impacting on business and service provision in most of the local municipalities. The Economist (2016) reports that South Africa's gross domestic product decreased by 3% due to power crisis with cities on the receiving end as they fail to provide services. The on-going power outages are severe especially for state owned entities with the situation likely to persist beyond 2016 despite new projects on power generation (Tsimane, 2009:5). The most critical challenge for state entities lies in the distribution of electricity to the respective communities. The challenge is not peculiar to South Africa alone; most of the SADC member states that includes Zimbabwe, Malawi and Tanzania are in a deep power crisis. The Democratic Republic of Congo (DRC), although rich with the Congo River for hydropower, is struggling to supply its economy. This is a sad story as DRC through its Congo River could power the entire African continent and the World (Economist, 2007). In summary the entire SADC region is in a severe electricity generation challenge with some entities in South Africa experiencing the worst ever power crisis of the century (Tsimane, 2009:5).

## **2.11. Evaluation of an Alternative energy and Future Trends in Renewable Energy**

Malaysia has a diversified energy resource including fossil fuel and various renewable energy sources such as hydro, biofuel, solar etc. (Aziz et al: 2016). Solar radiation in Malaysia is approximately 4 500 kWh per square meter at an abundance of 12 hours a day. The annual average of solar radiation is estimated at 1 643 kWh for applications such as water pumping, water heating and drying process for agricultural crops. The solar system is normally installed at the point of use. In 2005, the government of Malaysia has introduced Malaysian Building Integrated Photovoltaic Project (MBIPV) to encourage the installation of PV on the buildings. The program took almost five years and in 2006, MARA University of Technology was selected as the Photovoltaic System Monitoring Centre (PVSMC) whereby the performance of BIPV and PV projects under the MBIPV project are monitored. In South Africa, Limpopo province has experienced partial growth in spreading of biogas technology due to lack of awareness (Uhunamure, Nethengwe and Tinarwo: 2020). Regardless the history biogas technology, there has been poor development witnessed in application of the biogas technology in other parts of the country and the Limpopo province in particular.

Ghanaian Energy commission has been assigned to review the investment plan to warrant the sustainability of the energy needs through the strategic national energy plan between 2006 and 2020 (Oduro, Gyamfi, Sarkodie, Kemausuor: 2020). The objective was to provide a comprehensive energy market and to sustain the energy provision in Ghana. In between the period announced, the objective of energy policy was also to increase the renewable energy share up to 10%

Energy demand outgrows the generating volume and thus make compulsory for the energy demands to be met and improved efficiently and firmly (Salvarli and Salvarli: 2020). Energy solutions must support through the renewable energy source and the alternative means. The developed countries tried to restructure their energy sector; however, they were faced with challenges such as cost, market share and policies. In order to succeed socio-economy and industrialisation must be supported by policies.

## **2.12 Development of Management plan Framework**

The word strategy has been tendered from military and refers to high level plan or otherwise it can be called tactics (Ehlers, Lazenby 2011:176). Ehlers further point to that what seems to be tactical toad may prove strategic tomorrow. It seems to be a lot of strategies in from the developed countries with regards to energy generation, distribution an application. Lately there are ongoing developments in the electrical energy industry and the replacement or alternatives to the existing energy production by means of an alternative energy source, and the application of new technologies in the electrical energy sector. These developments comprise of solar photovoltaic, wind turbines, biogas etc., and on the newer technologies applications of electrical are energy efficient technologies to provide the same energy output with less input energy. Strategies have been developed to for improvement; furthermore, they became modern tactics that enhanced the development of strategic plan.

The appropriate management strategic plan comprises of their tier process that involves corporate, business, functional level planner and support personnel according to (Pearce ii, Robinson Jr. 2015). Pearce further indicated that the process centers on the organisational or institutional beliefs objectives can be accomplished by an organised and a wide-ranging assessment of both internal and external environment. The development of management plan frame work is aligned of the energy management plan and the implementation is synchronous.

## **2.13 Business plan analysis Framework (SWOT analysis)**

The business plan analysis framework, SWOT analysis is an acronym of that focuses on the internal Strength and Weaknesses of organizational environment, external Opportunities and Threats facing the organisation. It is a widely held practice through which management create an overview of a company strategic performance and position (Pearce ii, Robinson Jr. 2015). The organisation or firm has to maximise its Strength and Opportunities and minimise its Weakness and Threats to remain competitive and sustainable.

The Internal Factor Evaluation matrix (IFE) is utilised to enumerate the internal environments far as possible and to calculate the score for the organisation regarding its performance in the environment. The similar exercise is also done on External Factor Evaluation matrix (EFE) to quantify the organisational position relating to the external environments (Ehlers, Lazenby 2011).

The internal evaluation assists the firm to measure its strength and minimise weakness to maintain optimal performance. While external evaluation guides the firm in measuring the position of the firm through opportunities available for the firm to compete, and the threats the firm faces in the environment it operates.

## **2.14. Chapter summary**

This chapter give emphasis on scholarly literatures and reports that deals with the concept of a range of electricity and alternative energy production systems and their pros and cons of thereof. Furthermore, the chapter also outlines the concept of sustainability and the pillars of sustainability through the lens of electric production in fossil fuel and renewables.

The chapter also covers the history of electricity generation, impact on socio economy, the land scape of electricity industry in South Africa and the continent as whole, likewise the electricity as a commodity in service delivery i.e. concept and challenges in a service delivery and lastly the evaluation of alternative source of electrical energy and its future trends.

In this chapter, the current electric production management system which is coal based and gives focuses on renewable sources as an alternative energy production system. This further would positively impact on the economic, technology, environment, and politics, social, legal and ethical aspect of electricity and alternative energy production and consumption.

In conclusion, the literature review also cover-ups the development of management plan in line with energy management plan, and the SWOT analysis framework utilised for business plan analysis.

## **CHAPTER THREE: RESEARCH METHODOLOGY**

### **3.1. Introduction**

This research mainly aims to develop an energy management plan for Bloemfontein Centlec (SOC) Ltd, to lower its dependency on Eskom and supply its customers' demand. In order to achieve this objective, the main questions that need to be addressed are:

- Does Centlec have energy management plan in place?
- What is the status in energy consumption and demand for the previous decade and the projections for the next ten years?
- Are there any alternative (sustainable) energy production means for Centlec?
- How can Centlec adopt a new energy management plan? and
- How can Centlec become key player in power production as suggested by integrated resource plan (IRP) 2010-2030 and lower its dependency on Eskom?

Addressing these questions will provide a plan to Centlec to maintain the existing customers as well as producing power independently.

### 3.2. Research Method Flowchart

The business process approach is made up of a series of activities aimed at the systematic collection of information by making use of acceptable methods of analysis to draw conclusions (Mikalef and Krogstie, 2020). The business process was adopted in this chapter in order to clearly illustrate the methodological procedures followed in conducting this study.

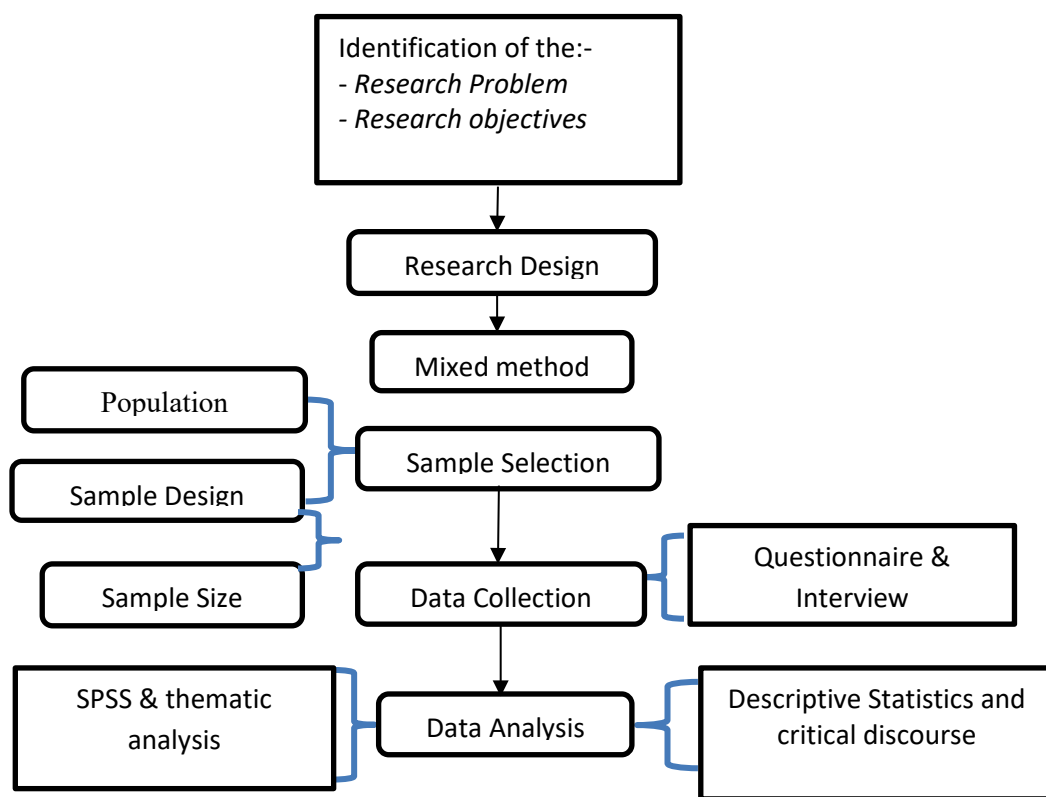


Figure 3.1: The business process (Ngek, 2015) (modified by the researcher)

### 3.2 Research design

In this research, both qualitative and quantitative research design otherwise known as mixed approach will be employed. In order to compare the reliability and validity of both the qualitative and quantitative data, *triangulation* model will be employed.

The mixed approach, strength and weakness as well as triangulation model are detailed as follows.

### *Mixed research design*

Quantitative studies are a type of scientific research. Hesse-Biber (2010) states that there is generally a process of investigation intended to answer a specific question. The examiners use a set of defined procedures to find the closest answer possible to the question. Research is very important in gathering evidence and, more importantly, data of different kinds. Moreover, a qualitative study aims to produce different findings that were not typically predetermined in advance, and the findings may be applicable beyond the very scope of the study (Strijker, et al., 2020).

Furthermore, qualitative study techniques aim to understand a problem or topic from the perspective of the general population with which the study primarily deals. Using the qualitative study method is an effective way of getting specific cultural data about the values, opinions, behaviors and other social contexts of a certain population (Strijker, et al., 2020). Using both quantitative and qualitative techniques, indicates that it helps to interpret and better understand a complex situation at hand (Strijker, et al., 2020).

### *Strength of mixed design*

It is often possible to extend the results of a qualitative study to people with characteristics similar to those of the study population, which gives a richer and more complex understanding of a particular context or phenomenon, which takes precedence over eliciting data that can be generalized to other geographical areas. The qualitative study progression is therefore different from general scientific research progression (Nachmias-Frankfort & Nachmias 2008; Strijker, et al., 2020).

Many researchers prefer the third and more preferred method of research because of its strengths. When using this method of research, both quantitative and qualitative strengths can be discovered. Furthermore, context can be added to numbers by using terms, pictures, and narratives. The use of mixed methods of research also allows

researchers to add precision to words, pictures, and narratives. In addition, researchers can generate and test a grounded theory when using the mixed method.

### *Weakness of mixed research design*

Since the researcher is not restricted within the confines of a particular method, the mixed method of research can be used to address a broader and more complete range of research questions. Researchers can also use the strength of one research method to overcome the weaknesses of another method. Essentially, this is a complementarity approach.

If a researcher uses this method for conjuring up a conclusion, they are in a better position to provide stronger evidence through convergence and collaboration of the findings. Moreover, the method of research is an opportunity for the researcher to add insights and methods that might be omitted when only one method is utilized. Similarly, the researcher can simplify their findings to increase their simplicity. Lastly, since mixed methods research is about integrating qualitative and quantitative methods of research, the researcher can produce more complete knowledge necessary to inform theory and practice.

### *Triangulation*

Usually, primary care research uses this particular model. In contrast to the sequential model, however, it is more difficult to integrate due to the need to not only reconcile but also bring back quantitative and qualitative data. This type of design model combines qualitative and quantitative methodologies simultaneously, thereby incorporating the two paradigms of research to fully grasp the situation at hand (Längler, Brouwer and Gruber, 2019).

Essentially, this design model provides an equal platform for both qualitative and quantitative research methods, which in other formats of research are usually separated into separate columns that may or may not be equal. Additionally, the triangulation model typically integrates the data gathered from both qualitative and quantitative methodologies into one all-inclusive and comprehensive report. This can either be summarized as a conclusion, interpretation, or results phase.

The triangulation design model is structured so that both qualitative and quantitative data can be accommodated in different sections. The results of both methodologies will be presented in the same format. Then, a thorough discussion of both data results is presented under the neo conclusion heading. As a result, researchers adopting this type of design model present both their results from different methodologies as contradictory evidence for their results. A researcher could also try to conglomerate the results by converting one type of data into another in line with a particular methodology (Längler, Brouwer and Gruber, 2019). Therefore, this study justifies the use of triangulation model due to the nature of data that will be collect and the need to integrate the result from different perspectives.

### **3.3. Sampling technique and design**

Sampling enables the researcher to select the representative elements of the entire population in order to draw conclusions (Chawla, Bowyer, Hall & Kegelmeyer, 2002). A population is defined as a group of people or entity that has the characteristics for which the researcher is looking or relevant to the study (Welman et al., 2005:52). Permission will be requested from Centlec, with the inclusion of utilisation of correspondence emails, database and other information (customer energy demand) that may be required in conducting the study in line with the POPI act.

Firstly, in total, 12 Centlec middle management and/or higher, will be interviewed on issues of the current energy management plan and its effectiveness; current strategies to supply the rising energy demand; and the need for alternative energy production due to the rising environmental concerns in the fossil fuel based power production. The sampling will include the office of CEO of Centlec, Human resource directors, head of finance, head of compliance and performance, head of engineering wires and head of engineering retail. Such sampling technique is known as purposive sampling technique. Purposive sampling ensures hand-picking subjects on the basis of specific characteristics and balances of group sizes when multiple groups are to be selected (Campbell et al., 2020).

Secondly, the external consultants are mainly consisting of experts in energy production management and those who are experts in environment and alternative energy. In total, 6 external consultants will be interviewed on issues similarly presented to key personnel. However, none of the external consultants will have any professional or personal ties with Centlec. Purposive sampling technique will be employed as it ensures hand-picking subjects on the basis of specific characteristics.

Lastly, 320 customers will be contacted for the survey data collection which is the quantitative aspect of the research. The sample size has been determined by making use of Raosoft online sampling software (Raosoft, 2022). The statistical workings of the Raosoft sampling as well as the number of interviewees from Centlec is explained in detail in chapter three. Stratified sampling technique will be employed for the survey. Stratified random sampling consists of dividing a population into smaller subgroups called strata. Stratified random sampling, or stratification, divides the sampled population into groups based on attributes or characteristics (Parsons, 2014). Therefore, the survey will be distributed randomly to businesses as they comprise the highest energy consumption.

The advantages and disadvantages of using both purposive and random stratified sampling summarised in the table below.

Table 3.1: Advantages and disadvantages of sampling techniques (Etikan, Musa, & Alkassim, 2016)

<b>Sampling</b>	<b>Definition</b>	<b>Advantage</b>	<b>Disadvantage</b>
<b>Stratified random</b>	Random sample from identifiable groups (strata), subgroups, etc.	Can ensure that specific groups are represented, even proportionally, in the sample(s) (e.g. by gender), by selecting individuals from strata list	More complex; requires greater effort than simple random sampling; strata must be carefully defined

<b>Purposive</b>	Hand-pick subjects on the basis of specific characteristics	Ensures balance of group sizes when multiple groups are to be selected	Samples are not easily defensible as being representative of populations due to potential subjectivity of researcher
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### 3.3.1. Sample size determination

#### *Quantitative*

In calculating the sample size, this study made use of the Raosoft sample size calculator (2020). Raosoft is statistical software used in calculating the sample size. Raosoft takes into consideration four factors when determining the sample size. These factors include: the margin of error, the confidence level, the population and the response distribution, since it is the size that gives an acceptable credibility level. These factors are explained in detail below (Raosoft, 2020).

- The margin of error (confidence interval) is the total amount of error the researcher can tolerate, with 5% being the common choice.
- The confidence level is the number of uncertainty the researcher can tolerate.
- The population size is the number of people to be chosen from the researcher's random sample.
- According to Centlec 2020, the utility in Bloemfontein offers 1 850 businesses and bulk user's electricity in the city.
- The population of 1 850 businesses and bulk users were used as the population size for this study.

- The response distribution is the expected result the researcher intends to get from each question. Fifty percent is usually used as the response distribution as it gives the largest sample size.

Therefore, using the Raosoft sample size calculator, the margin of error was taken to be 5%; the confidence interval of 95%; a population of 1 850 businesses and the response distribution of 50%. These formulas gave the researcher a sample size of 319 when using the Raosoft sample size calculator, which was then used as the sample size of the study. This sampling technique however, only applies to quantitative analysis. This sample size is chosen in order to facilitate meaningful analysis in light of time and resource limitations, as well as enable the sample with reasonable accuracy, to reflect the thinking, opinions, attitudes and behaviour of the entire population.

### *Qualitative*

In qualitative sampling there are no consensuses on a specific number of sample as a representation. However, as a general rule, in qualitative research the researcher should sample until getting no more any new information or insights. With careful sampling and equally careful collection techniques, a surprisingly small number of interviews, narratives, or focus groups can yield the data needed to answer the research question. Therefore, the researcher will attempt to obtain to gather enough in-depth information by carefully selecting the participants (Hafsa, 2019).

## **3.4 Data Collection**

According to Lobe *et al.*, (2020), data collection is defined as a process of gathering information on variables of interest. Data can be broadly categorized in terms of its source, primary and secondary data, both of which will be used by the researcher in conducting this study.

### **3.4.1 Primary data**

Primary data refers to first-hand information gathered about the subject or entity to be studied (Groenland and Dana, 2020). According to Blom et al. (2020), primary data can be obtained by means of three major components: observation, experiment and survey. Primary data can also be collected in several ways, such as checklists, surveys, questionnaires, interviews, observations, focus groups, case studies and documentation review (Moises, 2020). As mentioned earlier, questionnaires and personal interviews will be the main tools to obtain primary information for this research.

A survey of self-administered questionnaire will be conducted. The data collection process will take place via email obtained from Centlec's database. Survey respondents will be required to be Centlec Ltd clients, specifically bulk electric consumers. The Centlec 2020 business plan shows that businesses that uses bulk electricity are the once mainly switching to using solar panels.

The objectives of this study as well as the research variables, including varying theoretical constructs will be used to develop the questionnaire and the interview questions.

### **3.4.2 Secondary data**

Secondary data is second-hand information that has been gathered and readily available for upcoming research projects. According to Smith (2008), secondary data is primary data that was collected by someone else or for a purpose other than that of the current one. All of the secondary data used in this study has been obtained from books, academic or scientific journals (both local and international), annual government reports and verified or published research papers.

### **3.5 Data Analysis**

Data analysis plays a significant role as it simplifies this research into defensible, actionable sets of conclusions and reports, thereby unleashing the potential of 'new' knowledge. The nature of data analysis is a set of techniques and methods that can

be used to attain information and infer insights from data (Kenny, Kashy and Cook, 2020).

This research will make use of SPSS for quantitative analysis and inductive content analysis (line-by-line coding) for qualitative analysis. The quantitative result will be shown in form of descriptive statistics (percentages, frequency distribution tables, histograms and charts) and inferential statistics (cross-tabulation, correlation and Analysis of variance etc.), and the qualitative result will be presented in narratives from the transcriptions of the interviews.

### **3.5.1 Descriptive statistics**

Descriptive statistics are statistical outputs that provide a demographic illustration of the general sample population (Kent, 2020). Types of descriptive statistics that will be used in this study include frequencies, percentages, charts and histograms in order to extract demographic information.

### **3.5.2 Inferential statistics**

Inferential statistics explain the deeper relationship between the variables and help the researcher to make judgments about the population and draw conclusions (Kent, 2020). Forms of inferential statistics that will be analyzed in this research include cross-tabulation, correlation and statistical reliability, as well as validity.

### **3.5.5 Thematic content analysis**

Thematic analysis is a form of qualitative data analysis that involves reading through a set of data (such as transcripts from interviews or focus groups) and identifying patterns in meaning. Researchers' subjective experiences play a key role in constructing meaning from data in thematic analysis, which involves an active process of reflexivity. Thematic analysis requires step by step process. Each process are

explained as follows;

- Familiarize yourself with the data
- Create your initial codes
- Collate codes with supporting data
- Group codes into themes
- Review and revise themes
- Write your narrative

### **3.7 Conclusion**

The methodology chapter deals with a series of activities and procedures that will be carried out in order to achieve the objective of this study. The primary objective of this study is to investigate which alternative energy sources are viable to develop an energy management plan for Bloemfontein Centlec (SOC) Ltd, to lower its dependency on Eskom and supply in its customers' demand. In order to achieve this objective, both qualitative and quantitative research methods will be employed. Furthermore, the study will make use of a questionnaire and one on one interviews as data collection tools. Finally, the data gathered data will be analyzed by using SPSS for the quantitative data and thematic content analysis for the interview data which will later be transcribed.

In the following chapter (Chapter 4), the results of the analysis will be presented and discussed in order to draw conclusions.

## **CHAPTER FOUR: RESULT AND DISCUSSION**

### **4.1. Introduction**

This chapter presents the analysis and results of the empirical data of the study. The

results were collated from questionnaires administered to 320 Centlec customers and six external consultants. In addition, 12 open ended interviews were conducted with middle and upper managements of Centlec. The 320 questionnaires administered, were in residential, commercial and industrial areas of Bloemfontein in the Mangaung municipality of the Free State Province; out of which 245 questionnaires were completed and used for the analysis. The analysis and results are presented within the research framework as specified by the literature review and the methodology. Furthermore, the descriptive and inferential statistics of the quantitative data were analysed by making use of SPSS version 28.0 while the structured interviews were analysed by using thematic qualitative analysis method.

The presentation of the empirical findings is divided into three sections. Section A reports the descriptive statistics of the study, while Section B and section reports on inferential results and qualitative results respectively. However, both the qualitative and quantitative results are weaved together in order to corroborate similarities and differences of responses.

## **4.2. Distribution**

The sample were drawn from the total number of Centlec clients in the city of Bloemfontein. The customers who responded to the questionnaires are residents, businesses and industries in the various regions of the Bloemfontein. Therefore, for a fairly representation the questionnaires were distributed Heidedal, Bainsvlei, Bayswater, Brandwag, Ehrlichpark, Fauna, Fichardtpark, Fleurdal, Gardeniapark, Generaal De Wet, Langenhovenpark, Helicon Heights, Bloemanda parts of Bleomfotein. In total, out of the 320 questionnaires administered 245 were competed which comprise 76.6% response rate.

## **4.3. SECTION A: DESCRIPTIVE RESULTS**

**Section A** presents discussions on the demographic information of the respondents

such as the customer categories (commercial, residential or industrial), location of customer's residents, businesses or industries, the use of power (large power user or small power user), application of power (residential, commercial and/or industrial) and power sources (either Eskom, captive generator, solar panel PVP etc.). Thus, the section presents the descriptive results of the empirical data. This involves reporting the characteristics of the location, spread and shape of various sets of data (Blumberg, Cooper and Schindler, 2011). Common forms of descriptive statistics include frequency counts (quantity), measures of central tendency such as the median, mean or mode, or a measure of dispersion (variation) such as standard deviation (Hair *et al.* 2016). Descriptive results are usually depicted on charts (bar charts, pie charts, line charts), graphs and tables (frequency distributions) (Hair *et al.* 2016).

#### 4.3.1. Categories

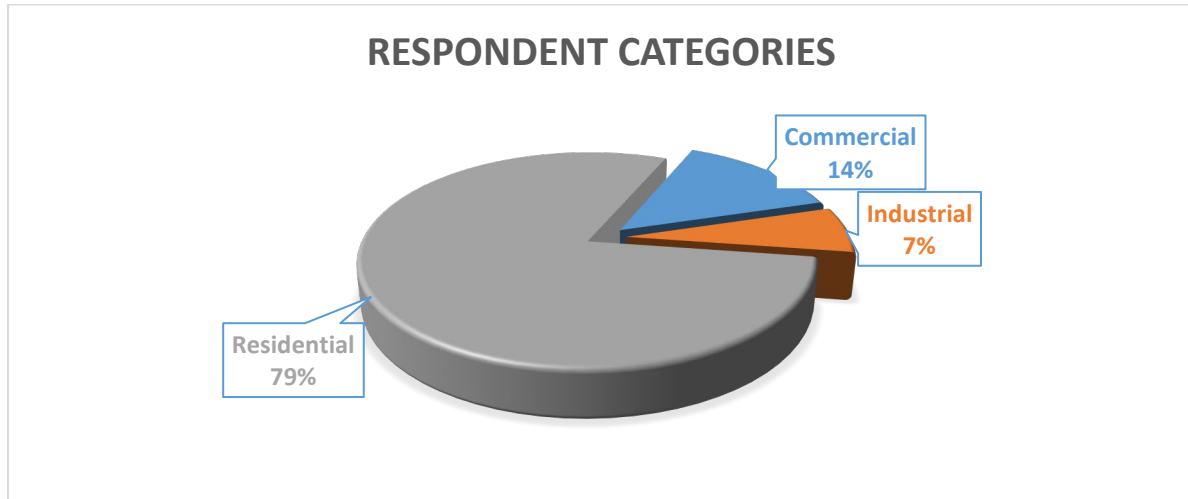


Figure 4.1. Respondent's categories by electricity use

Majority of the participants, which is 79%, are categorised as residential consumers. On the other hand, 14% and 7% of the respondents were commercial electricity consumers and industrial respectively.

### 4.3.2. Location

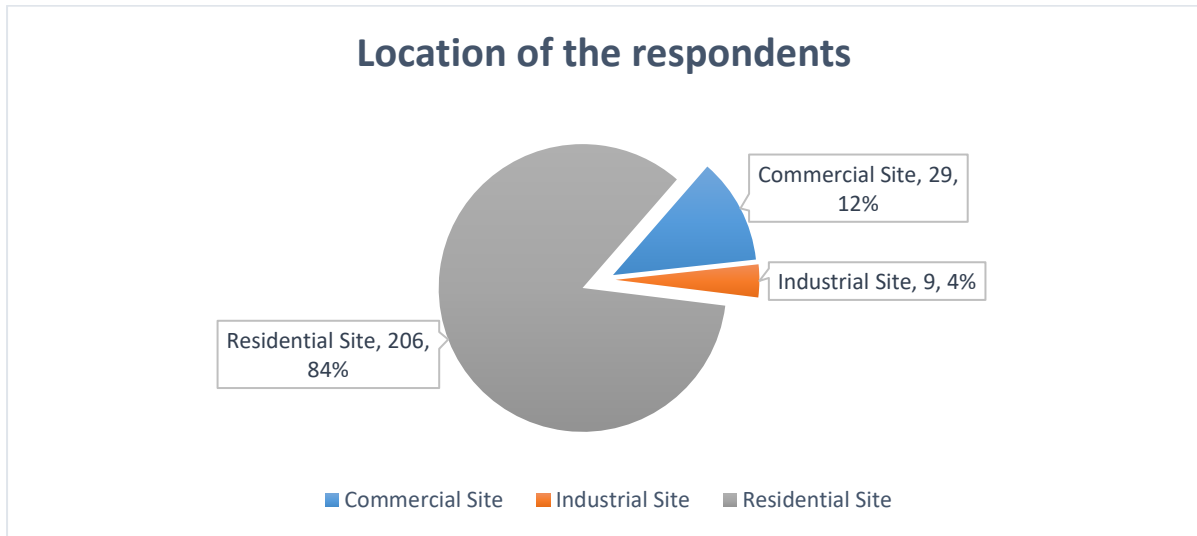


Figure 4.2. Location of the respondents

More or less similar to the categories above, 84% of the participants reside in residential site whereas 12% in commercial site and 4% in industrial sites. Participants of the residential site is slightly higher compared to categories of the participants since some business operate in the residential sites.

### 4.3.3. Power User

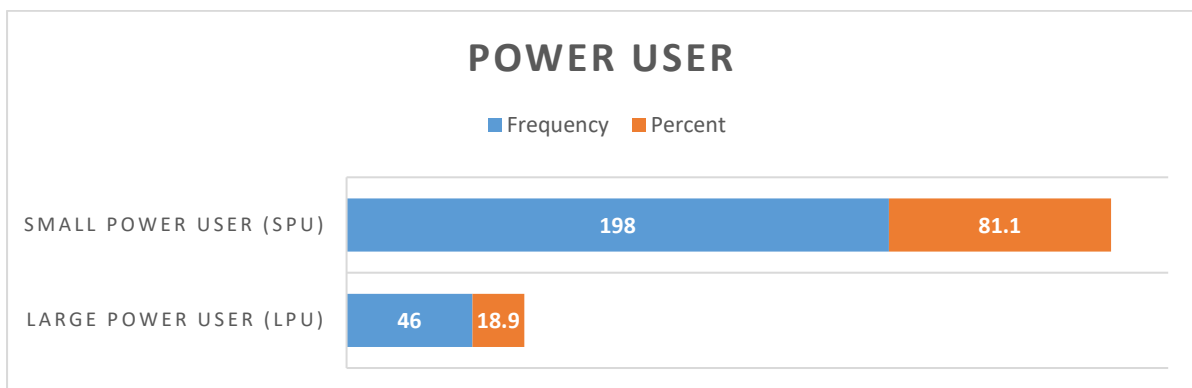


Figure 4.3. Respondents power use in unit

Majority of the participants, out of 244, 81% of them are small power users while the

remaining 19% were large power users. This result corresponds with Centlec's client's proportion by power use.

#### 4.3.4. Power Application

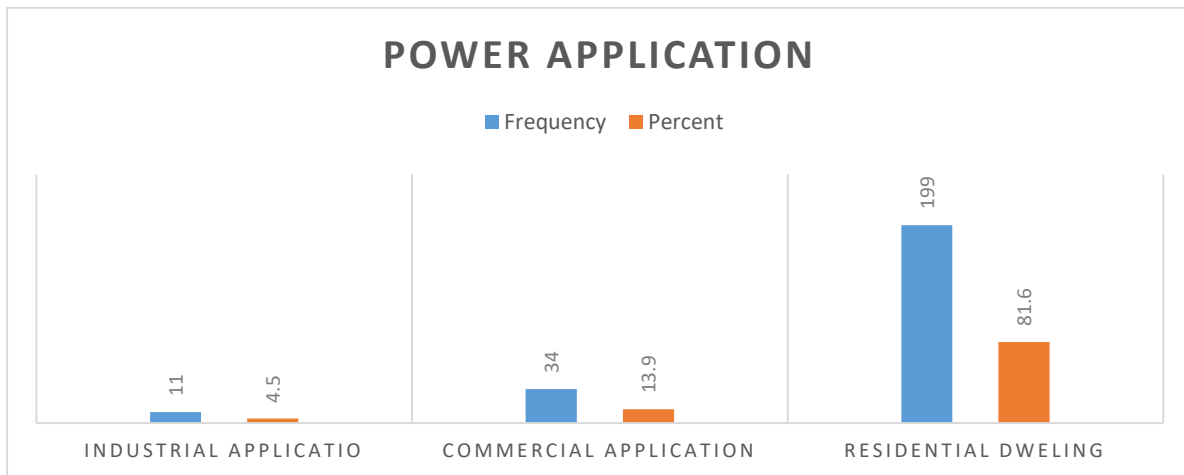


Figure 4.4. Purpose of electricity use

The participants identified the application of their power consumption by residential, commercial and industrial applications. According to the figure above, 81.6%, 13.9% and 4.5% of participants use electricity for residential, commercial and industrial applications respectively. This result corresponds with the power application proportions in the city of Bloemfontein and broadly in South Africa. However, per unit usage, business and industries consume large amount of power.

#### 4.3.5. Power Sources

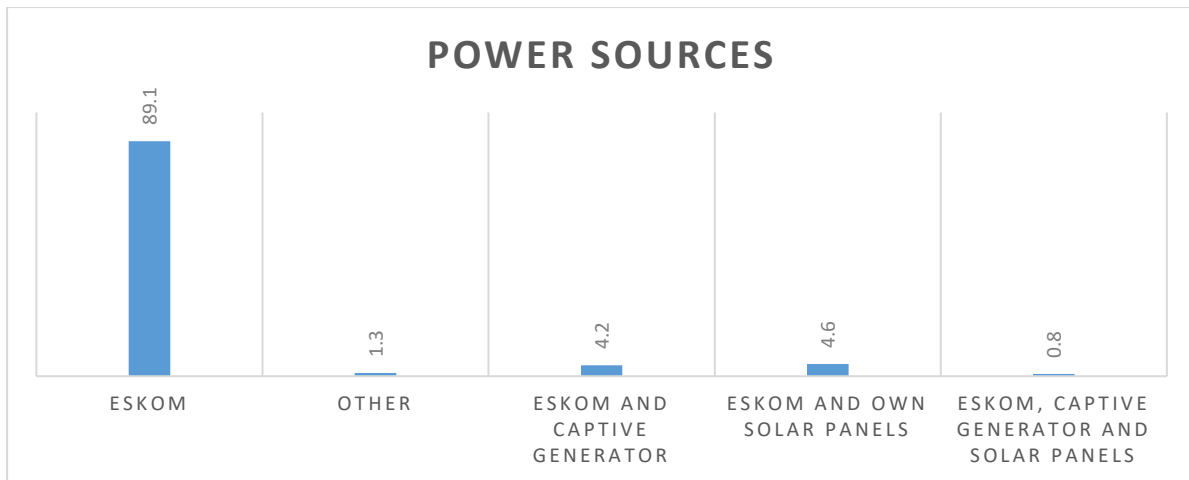


Figure 4.5. Power Sources

In recent years, consumers have several options as power sources. Among the total of 244 participants, 89% uses Eskom as their primary power source, followed by 4.6% use combination of Eskom and solar panel and 4.2% captive generator along with Eskom. The remaining 1.3% uses other sources and 0.8% uses all the three combinations of Eskom, captive generator and solar panels. It is crucial to note that all the subordinating power suppliers including Centlec were identified as Eskom power source as they retail power that they directly obtain from Eskom.

#### 4.3.6. Are you off-grid?

The figure below shows that how many of the participants are either entirely off-grid, partially off-grid or entirely dependent on the main-grid. The result shows that 88% of the participants are entirely dependent on the main grid while 10% were partially off-grid and only 2% of the participants were entirely off-grid. Furthermore, the reasons to go off-grid partially or entirely are presented in Table 4.1. Since only 12% of the participants were either off-grid or partially off-grid, the reasons to go off-grid were not applicable for slightly over 70% of the participants. However, among those who are off grid, either partially or entirely, 10% of them have chosen this avenue due to load shading. Moreover, 6.6% of the participant were off-grid due to combined reasons of high cost of electricity and load-shading whereas 5.3% were off grid for the sole reason of high cost of electricity.

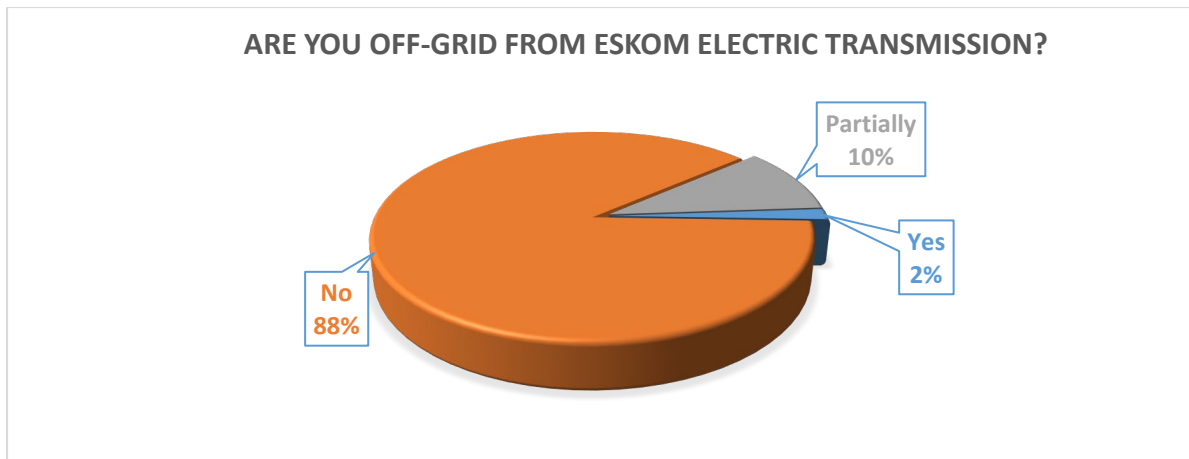


Figure 4.6: Are you off grid?

#### 4.3.7. Reasons for being off grid

Table 4.1. Reasons for going off grid

Reasons	N	%
Electricity was expensive	13	5,3%
Electricity was expensive and environmental concern	1	0,4%
Electricity was expensive and dues to load-shading	16	6,6%
Environmental concern	11	4,5%
Environmental concern and Load shading	5	2,0%
Load shading	26	10,7%
Other	1	0,4%
N/A	171	70,1%

#### 4.3.8. Awareness of coal combustion and its environmental impact

Out of the total of 244 respondents, 71% of the participants believe that coal-based power production is bad for the environment while the remaining 29% of the participant do not believe that coal based power production is bad is bad the environment.

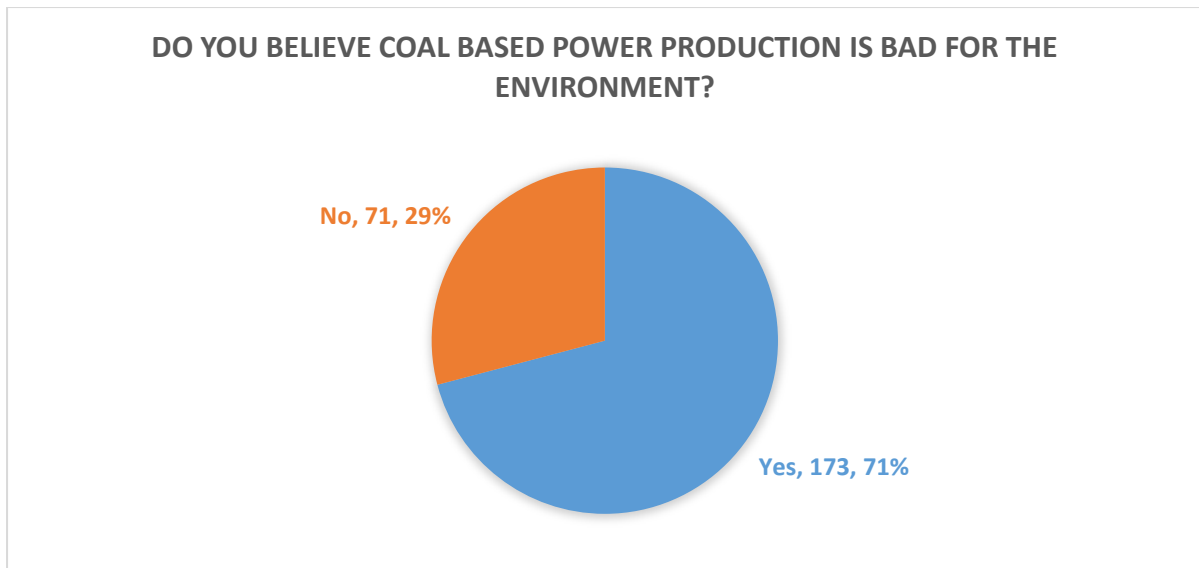


Figure 4.7. Coal is bad for the environment?

#### 4.3.9. Renewable energy and the environment

Table 4.2. Renewable energy and environment

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Electricity generated from renewable energy sources has a smaller environmental footprint than power from fossil-fuel sources.	45.5%	32.0%	13.9%	4.1%	4.5%
Using more renewable energy production is more beneficial to the environment than coal-based power production.	56.6%	24.2%	15.6%	3.7%	0.0%
South Africa should switch the bulk of its electric production to renewables such as solar, wind, geothermal, hydrological etc. for the sake of the environment.	43.0%	30.7%	20.1%	3.3%	2.9%
Sustainable development demands that we switch to renewable resources	45.5%	32.0%	16.4%	3.3%	2.9%

(renewable resources include, for example, wind power, solar panels etc.)					
Sustainable use of energy is essential for economic development	54.1%	32.4%	13.5%	0.0%	0.0%
Renewable energy production is considered sustainable in the future	33.6%	39.8%	23.4%	2.9%	0.4%
Using coal-combustion to produce energy is economically sustainable.	15.2%	34.4%	32.4%	8.6%	9.4%
Using renewable energy production is economically sustainable	30.3%	37.3%	20.5%	5.7%	6.1%
Government regulations are essential for economic sustainability.	25.1%	47.3%	18.1%	8.2%	1.2%

The above Table shows that the level of agreement indicated by the participants concerning renewable energy and the environment. The responses were, collectively, 77.5% of the participants agree or strongly agree that electricity generated from renewable energy sources has a smaller environmental footprint than power from fossil-fuel sources. On the other hand, 13.9%, 4.1% and 4.5% of the respondents were neutral, disagree and strongly disagree with the statement, respectively. Furthermore, only 3.7% of the participants disagree that using more renewable energy production is more beneficial to the environment than coal-based power production, whereas 15.6%, 24.2%, and 56.6% were neutral, agree and strongly agree, respectively.

Majority of the participants, 73.7%, either agree or strongly agree that South Africa should switch the bulk of its electric production to renewables such as solar, wind, geothermal, hydrological etc. for the sake of the environment. The remaining 20.1% were neutral and only 6.2% either disagree or strongly disagree.

The level of agreement expressed to the statement “Sustainable development demands that we switch to renewable resources (renewable resources include, for example, wind power, solar panels etc.)” were 45.5%, 32%, 16.4%, 3.3% and 2.9% strongly agree, agree, neutral, disagree and strongly disagree respectively. In addition, 54.1% of the participants strongly agree that sustainable use of energy is essential for economic development, while the remaining 32.4% agree and 13.5% neutral.

Out of the total responses, 33.6%, 39.8%, 23.4%, 2.9% and 0.4% strongly agree, agree, neutral, disagree and strongly disagree that Renewable energy production

is considered sustainable in the future, respectively. However, subsequently, 15.2% strongly disagree, 34.4% agree, 32.4% neutral, 8.6% disagree 9.4% strongly disagrees that using coal-combustion to produce energy is economically sustainable. On the other hand, the participants, 30.3%, 37.3%, 20.5%, 5.7%, 6.1% subsequently- strongly agrees, agrees, neutral, disagrees and strongly disagrees that using renewable energy production is economically sustainable. Lastly, 72.4% of the respondents agrees (strongly agree and agree) that government regulations are essential for economic sustainability, except 9.2% of the participants disagree.

#### 4.3.10. Social Acceptability

Table 4.3 Social Acceptability

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Coal-based power production plants are acceptable to me.	8.6%	45.1%	28.3%	11.5%	6.6%
Emissions from coal power plants are hazardous to health of the community around it.	34.4%	41.8%	16.8%	7.0%	0.0%
Renewable energy is more acceptable than coal-based power production.	31.1%	44.3%	18.4%	5.7%	0.4%
The waste management in the areas of Eskom coal power stations are not efficient.	21.7%	19.7%	45.1%	10.2%	3.3%

Over 53% of the participants agrees that coal-based power production plants are acceptable while 18% of disagree and 28.3% were neutral. Similarly, 34.4%, 41.8%, 16.8%, and 7.0%, strongly agrees, agrees, Neutral and disagree that emissions from coal power plants are hazardous to health of the community around it. This result shows that majority of the participants are aware of the hazardous nature for coal plan emissions. All things considered, slightly over 75% of the participants either agree or strongly agree that renewable energy is more acceptable than coal-based power

production. Lastly, it is alarming that only 41.4% of the participants agrees that the waste management in the areas of Eskom coal power stations are not efficient. Contrarily, 45.1% of the participant were neutral and 13.5% disagrees that the waste management in the areas of Eskom coal power stations are not efficient.

#### 4.4. SECTION B: INFERENTIAL RESULT

In this section, the relationship of different variables are presented in pearsons correlations and univariate analysis.

##### 4.4.1. Correlations

Table 4.4. Correlations

Correlations					
		Sustainability of Renewable Energy	Sustainability of Coal power production	Government initiatives to renewable energy	Environmental Sustainability of renewable energy
Sustainability of Renewable Energy	Pearson Correlation	1	.296**	.666**	.317**
	Sig. (2-tailed)		<,001	<,001	<,001
	N	244	244	243	244
Sustainability of Coal power production	Pearson Correlation	.296**	1	.441**	.191**
	Sig. (2-tailed)	<,001		<,001	.003
	N	244	244	243	244
Government initiatives to renewable energy	Pearson Correlation	.666**	.441**	1	.418**
	Sig. (2-tailed)	<,001	<,001		<,001
	N	243	243	243	243
Environmental Sustainability of renewable energy	Pearson Correlation	.317**	.191**	.418**	1
	Sig. (2-tailed)	<,001	.003	<,001	
	N	244	244	243	244

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Table 4.4. Show that there is a strong positive relationship between sustainability of renewable energy with government initiatives to renewable energy with a statistical significance of  $p=0.001$  which is below the threshold value of  $P \leq 0.005$ . Similarly, sustainability of coal power production and environmental sustainability of renewable energy have a moderate positive relationship with government initiatives to renewable energy with Pearson correlations of 4.41 and 4.18 respectively. This result indicates that government initiatives to renewable energy plays a significant role in reducing carbon emissions as well as integrating renewable energy.

#### 4.4.2. Univariate Analysis (Two way ANOVA)

Table 4.5. Univariate analysis

Tests of Between-Subjects Effects						
Dependent Variable: Sustainability of Renewable Energy						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	614.284 <sup>a</sup>	4	153.571	21.601	<,001	.266
Intercept	2720.713	1	2720.713	382.697	<,001	.616
SA5	206.414	2	103.207	14.517	<,001	.108
SA6	394.017	2	197.009	27.711	<,001	.188
SA5 * SA6	.000	0	.	.	.	.000
Error	1699.126	239	7.109			
Total	17738.000	244				
Corrected Total	2313.410	243				

a. R Squared = .266 (Adjusted R Squared = .253)

SA6 = Satisfaction with the current electricity price

SA6 = Stabilising the current electricity price with the introduction of renewable energy  
Sustainability of renewable energy as a dependant variable, SA5, SA6 and the

intersectionality of both significantly impacts the sustainability of renewable energy with the statistical significance of  $p < 0.001$ .

#### **4.5. SECTION C: QUALITATIVE RESULTS**

This section presents the qualitative responses of consultants, middle and upper management of Centlec. The responses are divided in subsections. All the qualitative responses were analysed by making use of thematic analysis. However, the results are presented in form of narratives.

##### **4.5.1. Environmental impacts of coal combustion**

South Africa's energy mix is dominated by coal, with power generation accounting for more than 80% of output making the country one of top-20 emitters of carbon dioxide worldwide. Coal-fired power plants emit more than 60% different hazardous air pollutants causing diseases and killing thousands of South Africans. Furthermore, the environmental impacts associated with coal combustion for power production are particulate emissions, ground level ozone, smog and acid rain. Coal constitutes mostly of carbon, which when burned, reacts with oxygen in the air to produce carbon dioxide, heat trapping gas. The release of carbon dioxide in the air works like a blanket, warming the earth above normal limits. Climate change is coal's most serious long-term, global impact.

##### **4.5.2. Economic impacts of relying on coal combustion**

Beyond electricity production, coal can also contribute towards building modern cities and economies as it is an essential in raw material for iron and steel production, a key energy fuel used in cement production, aluminium and other highly energy intensive industrial products essential to building modern economies and urban infrastructure. Furthermore, coal combustion for power production can also encourage industrial competitiveness with lower energy prices as a key factor. Lower cost electricity produced from coal will result in lower production costs, thus increasing profits for

industry (and thereby the country), further promoting economic activity.

#### **4.5.3. Factors for the increasing demand of electricity in Bloemfontein**

South Africa's gradual move from dependence on traditional energy to advanced energy, the higher levels of economic growth experienced in 1990 and the emerging commitment of the government to higher electrification, have brought about an across the board rise in electricity demand. From an economic point of view, demand for any good or service is dependent on its price, prices of the buyer, and many other variables. Understanding the determinants of electricity demand, income and price, are essential for projecting current and future demand. Bloemfontein and Mangaung as one of the developed provinces in South Africa, makes the province heavily reliant on electricity and this is reflected by the province's social, economic, behavioural patterns and dwelling physical factors related to energy. Furthermore, an online article titled examining the determinants of electricity consumption in the nine South African provinces. A consultant further added:

“When analysing the provincial electricity demand, GDP, an indicator for real income in each province, was found to be statistically significant in explaining electricity demand in all provinces, and this can be supported by the Free State Provincial real GDP increase by 1.3%(q-on-q) in 2021Q2, following another positive growth of 3.5% in 2021Q1 thus the increase in electricity demand in Bloemfontein and Mangaung”

#### **4.5.4. Energy management plan in place**

Centlec does not have an energy management plan per se, however it does have a business plan projecting the growing demand of electricity. The core of the utility's inability to meet the growing demand of electricity, is poor governance, corruption and politics, and addressing these challenges which have plagued the utility should be the short-term plan. The long-term plan for Centlec to meet the growing demand, is for the utility to follow suite on developments in the electricity industry, which is the integration of renewable energy by generating and procuring electricity from private generators

thus reducing the pressure on the strained South Africa's electricity's system and diversify the utility's energy mix

#### **4.5.5. Energy management plan by Centlec to increase the use of renewable energy sources to meet the electricity demand**

Centlec does not have an energy management plan to increase the use of renewable energy sources. In its 2020-2023 business plan, Centlec acknowledged that solar and gas alternatives were becoming increasingly popular, and that it could no longer rely solely on Eskom to provide power. A feasibility study was mentioned in the document. According to Centlec's annual report for 2020 to 2021, an unnamed solar farm project had not started, but that a study costing R1.8 million would continue. As early as this year, Centlec was focusing more on implementing a turnaround strategy to deal with rampant irregular spending. No progress from Mangaung's Centlec on finding alternative energy sources.

The respondents clearly articulated that there are no current initiatives that Centlec considers as energy management plan.

#### **4.5.6. Alternative electricity Sources for South Africa**

South Africa's electricity power system is at a very precarious stage with most of Eskom's coal fleet constantly breaking down due to the fleet being old and lack of maintenance, and this call for an urgent deployment of other energy sources which can be deployed quicker, at a lower cost than your conventional sources such as coal or nuclear. Variable/varying renewable energy sources such as solar & wind which South Africa has in abundance, can contribute towards addressing the energy security crisis. Furthermore, sources of energy such as solar and wind are also low in carbon can also assist in mitigating climate change

#### **4.5.7. Challenges facing Eskom and Centlec in implementing the environmental policy**

Substantial investment is required for power generation's long-term planning by power generators and at the same time, their strategies are greatly affected by regulatory decisions where a substantial part of the market is regulated or impacted by regulatory decisions (e.g., subsidies) In respect to Eskom, which does have an environmental policy in place, the challenge in fully implementing their environmental policy, lies in the lack of right balance between security of supply, environmental impact and energy costs which must be found for the utility and its participants for the utility to be sustainable

Eskom does monitor and regulate compliance of sub-suppliers (Centlec) with corporate environmental policies (greenhouse gas emissions, wastewater, hazardous chemicals, etc.). However, the procedures in which Eskom monitors safety, health and environmental concerns are not clearly articulated. Rather focuses more on case-by-case basis.

#### **4.5.8. Measures Eskom and Centlec take to lower the emission when producing energy**

Addressing and dealing with GHG emissions requires a shift in the energy mix, by combining lower-carbon-emitting technologies such as renewables and gas. Eskom as South Africa's biggest greenhouse gas emitter, carries a huge responsibility towards lowering greenhouse gases, and one the biggest measure the Utility will be undertaking and as part of aligning with the Just Transition, is repurposing of its coal-fleet in Mpumalanga to solar and wind. The utility will retire 22GW of its coal-fired plants by 2035, reducing emissions by 62%. In respect to Centlec, there's currently no measures/ plan from the utility on how to lower GHG emissions, as the utility also doesn't have a plan in place, to integrate renewables.

#### **4.5.9. Reliability of renewable energy production for South Africa**

It is very much possible for South Africa to switch to renewable energy production, and a no brainer that South Africa has solar and wind resources in abundance. According to a study conducted by CSIR on Wind and Solar PV Aggregation for South Africa, the potential to produce electricity from wind turbines is significantly greater and more

widely spread than initially thought. The study results also show that across South Africa, solar photovoltaic (PV) and wind resources are good enough to be able to produce globally competitive solar and wind and that over 80% of the land mass has enough potential to achieve a 30% average annual load factor.

## **CHAPTER FIVE CONCLUSION AND RECOMMENDATIONS**

### **5.1. Introduction**

A shift towards more secure, affordable, and sustainable energy systems represents one of the greatest challenges of our generation, and there is therefore a need for a comprehensive analysis of the impacts of integrating renewable sources of energy generation into the current system.

The purpose of this study is to develop an energy management plan for Bloemfontein Centlec (SOC) Ltd as a way of reducing its dependence on Eskom and ensuring that its customers are supplied with energy on a consistent basis. Thus, the summary of the empirical findings, conclusion and recommendations are presented in this chapter.

### **5.2. Summary of empirical findings**

#### **5.2.1. Electricity usage and distribution**

Chapter four presented the empirical findings. The main highlights of the analytical result shows that majority of Centlec' s customers are small unit power users utilizing power mainly for residential purpose. Slightly over 88% of the participants access electricity from Eskom through Centlec, while the remaining either use Eskom and solar panel mix or Eskom, solar panel and captive generators. Among those that are partially or entirely off grid, majority of them chose that to be off grid mainly due to load-shading and the hiking of the cost of electricity or both. In addition, majority of the participants believe that renewable energy is sustainable to the future development.

### 5.2.2. Impact of coal combustion

The production of power in South Africa is highly dependent on coal. The infrastructure for coal mining has been in existence for a long time and for that reason it is cheaper currently to produce electricity using coal than renewables. However, the future impacts are great if we continue using coal as they have a negative effect on the environment. It costs more to deal with damages caused by emissions of GHGs than changing to renewables now. Green energy is what is needed for a sustainable future.

It is a well-known fact that fossil fuels are the main cause of Green-House Gas (GHG) emissions and coal is one of the biggest emitters. South Africa has one of the highest coal deposits in the world. Our current electricity demand is around 47 GW and the electricity supply, through Eskom, is dependent over 80% on coal. GHGs are the biggest problem to Climate Change and countries like South Africa are part of the Congress of the Parties COP assigned by the United Nations Framework for Climate Change UNFCCC to fight to reduce its fossil fuel emissions in order to slow down climate change impact. The impact would cause global warming which has an adverse impact on the ecosystem like rise in ocean levels causing floods, excessive heat causes the melting of glaciers, depleted sea life and many other environmental issues.

Generally, the environmental impact of coal combustion are;

- Sulphur dioxide (SO<sub>2</sub>), which contributes to acid rain and respiratory illnesses
- Nitrogen oxides (NO<sub>x</sub>), which contribute to smog and respiratory illnesses
- Particulates, which contribute to smog, haze, and respiratory illnesses and lung disease
- Carbon dioxide (CO<sub>2</sub>), which is the primary greenhouse gas produced from burning fossil fuels (coal, oil, and natural gas)
- Mercury and other heavy metals, which have been linked to both

neurological and developmental damage in humans and other animals

- Fly ash and bottom ash, which are residues created when power plants burn coal

And the socioeconomic impact of coal combustions.

- Mine workers and those living close to mines usually get sick shortening their lives and later becoming a burden to the health system becoming extremely costly to treat the lives of TB
- In some cases where dumping occurs, we find that the fish may be poisoned impacting the fishing industry. Government then has to subsidise those communities which is costly
- Future generations will be heavily impacted by global warming from the carbon dioxide that burning coal spews into the air.

### **5.2.3. Increasing demand of Electricity in Mangaung**

Mangaung Municipality currently procures most of its energy from Eskom which produces electricity via coal. Government has now allowed Municipalities to procure their own power from independent power producers provide they are from renewables. The demand in electricity in Mangaung is synonymous with the increase in demand in the country caused by economic growth. To cater for this demand, Mangaung should look in to procuring its energy from renewables or build their own renewable energy plants. However, there are no any plan by Centlec to bridge the gap in the increasing demand for electricity. More so, there is no tangible plan by Centlec to mix renewable energy in the grid or becoming an independent of Eskom by doing so.

### **5.2.4. Feasibility of Energy Sources for South Africa**

For a sustainable future, it goes without saying that South Africa, also as a member of COP, should start implementing its Integrated Energy Plan which was re-adopted in 2019 to include a solid energy mix which indicates a big move towards renewable

energy sources. In my opinion I believe we are not ready to go that route aggressively but should however start. We do not need to remove coal completely currently as the source of our energy production but add on as the economy grows. There are currently over 20 wind energy projects in the country and renewables accounts to more than 6% of our energy demand today. The process is a bit slow, but government is on a drive to accelerate this by reducing some red tapes experienced by IPPs and also looking into foreign investments. South Africa is on a drive to tremendously reduce the reliance of coal to around 60% by 2030. I however still maintain than we should not do away with coal as yet and have a proper energy mix that includes even nuclear energy sources

### **5.2.5. Environmental policy**

Eskom, the largest carbon emitter, has an environmental policy to regulate health hazards. However, it is evident from many reports that the implementation of the policy has not been successful.

Renewables are highly capital intensive and foreign investment is key in getting them off the ground. However, it is believed that the government is capable enough if serious, to start implementing from their fiscus. Smart technologies like smart metering should be use as tools to allow for this to speedily happen as it will encourage users with solar panels or any form of renewables to sell electricity back into the grid. The use of mini grids by smaller IPPs will also FastTrack this initiative.

### **5.3. Conclusion and Recommendations**

As a conclusion, this study has addressed three relevant questions that aim to evaluate the integration of variable renewable technologies and flexibility options in the transition towards a low-carbon and more efficient energy system in Bloemfontein and broadly in South Africa. It is important to interpret the findings of this study with caution. The researcher suggests a pathway for the future energy production of the city/country based on renewable energy sources to bridge the gap of the increasing electricity demand. The results of this study will be of much assistance to policymakers

from Eskom to its subsidiaries such as Centlec that are developing a roadmap towards low carbon energy production in Bloemfontein and other South African cities and provinces with similar potential and characteristics. Finally, the energy production in every province must be supported by dedicated policies and measures. Therefore, based on the results, the following energy management recommendations are outlined

- A more inclusive and ambitious national renewable energy plan should be formulated. Existing policies focuses primarily on the power sector, while support for sustainable alternatives in the heating, cooling and transport sectors lags. Specific targets for each of the energy sectors are key in order to achieve a renewable energy integration and transition.
- Fiscal and financial incentives are required for accelerating the adoption of the alternatives proposed in this work, and these include subsidies, grants and carbon taxes. Financial incentives are also important for supporting research and development of alternatives energy sources.
- A provincial national renewable energy roadmap should be developed. Renewable energy source holds a great potential in South Africa for the development of the power. In particular, an increase in the solar and wind energy, such as the proposed in this work, could represent important benefits in decarbonising the power production, supplying the increasing electricity demand and independence of subsidiaries such as Centlec to supply its own power to customers.
- The COVID-19 crisis is expected to have a significant negative impact on the global economy in the following years. However, it also represents an important opportunity for national governments to boost a green recovery by shifting the fiscal recovery packages towards sustainable development options. These options could include investments in clean infrastructure (grid modernisation and expansion, large-scale energy storage and CCS), improvements in building efficiency and an additional support for clean energy research and development projects.

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## **APPENDIX I: Questionnaire for the General Participants**

**Dear respondent**

Thank you for agreeing to participate in this interview. The title of this research is **An Energy Management plan for Centlec (SOC) Ltd in the Mangaung Metro (Bloemfontein)**. The study aims to determine if renewable energy such as solar, wind, geothermal etc., is viable to substitute coal based power production while the increasing demand of electricity is being met. The information gathered will only be used by the researcher for the purpose of this study. Any response will be treated with the strictest confidentiality. The researcher is conducting the study in accordance with the requirements for the Master's degree in Business Administration, at the University of the Free State. Please be as accurate and as honest as possible in answering all the questions. Your cooperation is highly appreciated.

Thank you for your time.

**Researcher: Mokoena Sefale**

**Supervisor: Mark J Peters**

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## QUESTIONNAIRE

### Section A: Demographic Information/ Customer Classification

Indicate your response with a cross(X) next to the appropriate answer.

#### 1. What customer category/custom base?

Commercial	1
Industrial	2
Residential	3

#### 2. Where is the customer located?

Commercial Sites	1
Industrial site	2
Residential sites	3

#### 3. What is the classification of customer?

Large power User (LPU)	1
Small Power User (SPU)	2

#### 4. What are the applications of energy in the premises?

Industrial energy application	1
Commercial energy application	2
Residential dwellings	3

**5. What energy source do you use?**

1. From Eskom	1
2. Captive generator	2
3. My own wind power	3
4. My own Solar power- roof top PV	4
5. Geothermal	5
6. Other, please specify	6

Please motivate your answer if you choose an energy source other than Eskom electric supply:

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**Section B: Environmental**

Indicate your response with a cross(X) next to the appropriate answer.

**6. Are you off-grid from Eskom electric transmission?**

Yes	1
No	2
Partially	3

**7. Why did you decide to go off-grid or partially off-grid?**

Electricity was expensive	
Environmental concerns	
Load shedding	
Other	

If you select other in the proceeding question, please provide reason/reasons as to why you decided to go off-grid either fully or partially?

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**8. Do you believe coal-based power production is bad for the environment?**

Yes	1
No	2

**9. Electricity generated from renewable energy sources has a smaller environmental footprint than power from fossil-fuel sources.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**10. Using more renewable energy production is more beneficial to the environment than coal-based power production.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	

5	Strongly disagree	
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**11. South Africa should switch the bulk of its electric production to renewables such as solar, wind, geothermal, hydrological etc. for the sake of the environment.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**Section C: Economic Viability**

**12. Sustainable development demands that we switch to renewable resources (renewable resources include, for example, wind power, solar panels etc.)**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	

5	Strongly disagree	
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**13. Sustainable use of energy is essential for economic development**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**14. Renewable energy production is considered sustainable in the future.**

1	Strongly Agree	
2	Agree	
3	Neutral	

4	Disagree	
5	Strongly disagree	

**15. Using coal-combustion to produce energy is economically sustainable.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**16. Using renewable energy production is economically sustainable**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**17. Government regulations are essential for economic sustainability.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**18. If you are off-grid, do you find being off-grid cheaper than Eskom supply?**

Yes	1
No	2
Not sure	3

**Section D: Social Acceptability**

**19. Coal-based power production plants are acceptable to me.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**20. Emissions from coal**

**power plants are hazardous to health of the community around it.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**21. Renewable energy is more acceptable than coal-based power production.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**22. The waste management in the areas of Eskom coal power stations are not efficient.**

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

**23. Are you happy with the current electricity price?**

Yes	1
No	2
Not sure	3

**24. Do you believe renewable energy sources will stabilize the current price of electricity?**

Yes	1
No	2
Not sure	3

**25. As an individual, do you believe you can contribute to the betterment of the environment?**

Yes	1
No	2

**If yes, How? Please explain.**

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**Thank You for Your Participation!**

## **APPENDIX II Questionnaire for Consultants and Management**

**Dear respondent**

Thank you for agreeing to participate in this interview. The title of this research is ***An Energy Management plan for Centlec (SOC) Ltd in the Mangaung Metro (Bloemfontein)***. The study aims to determine if renewable energy such as solar, wind, geothermal etc., is viable to substitute coal-based power production while the

increasing demand of electricity is being met. The information gathered will only be used by the researcher for the purpose of this study. Any response will be treated with the strictest confidentiality. The researcher is conducting the study in accordance with the requirements for the Master's degree in Business Administration, at the University of the Free State. Please be as accurate and as honest as possible in answering all the questions. Your cooperation is highly appreciated.

Thank you for your time.

**Researcher: Mokoena Sefale**

**Supervisor: Mark J Peters**

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1. What are environmental impacts of coal combustion for power production?

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2. What are economic impacts of relying on coal combustion for power production?

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3. What are the factors for the increasing demand of electricity in Bloemfontein and Mangaung Municipality broadly?

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4. Currently, is there an energy management plan in place for Centlec to meet the growing demand of electricity? If the answer is yes, what is the short term and long-term plan?

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5. Is there an energy management plan by Centlec to increase the use of renewable energy sources to meet the electricity demand? If so, how feasible is it?

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6. In your opinion, should South Africa focus on other means of electricity sources than coal, such as wind, solar, geothermal etc.?



9. Does Eskom monitor the compliance of sub-suppliers (Centlec) with corporate environmental policies (greenhouse gas emissions, wastewater, hazardous chemicals, etc.)? If so, what is the system in place to regulate?

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10. Emission from coal combustion is generally considered as detrimental to the environment. What measure do Eskom and Centlec take to lower the emission when producing energy?

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11. Do you believe it is possible for South Africa to switch to renewable energy production?

If yes or no, why?

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