

Greening the electricity sector: Barriers to the successful implementation of energy efficiency initiatives in South African Municipalities

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PREFACE AND ACKNOWLEDGMENTS

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ABSTRACT

Introduction: Greening of the electricity sector is one of the key critical responses to the pressing climate change, economic development, and electricity security challenges facing South African municipalities. The efficient use of electricity can be called green electricity. Many researchers have accepted that greening the electricity sector through energy efficiency improvement is one of the most cost-effective approaches toward sustainable electricity supply and reduction of the continuously increasing electricity consumption. This study contributes to a further understanding of how to pursue improvement in energy efficiency by describing and classifying barriers that hinder the successful implementation of energy efficiency initiatives in specific South African municipalities.

Aim: Stemming from the earlier work of Sorrell *et al.* (2000), this study aimed to describe and classify barriers that hinder the improvement of energy efficiency initiatives in specific South African municipalities. Furthermore, the study provided an overview of how municipalities can respond proactively to these barriers in the electricity sector. It is targeted at municipal energy professionals in selected municipalities.

Methods: An exploratory sequential mixed-method approach was employed in conducting the study. The data collection method employed a self-administered interview questionnaire to gather information from municipal energy professionals. Data analysis methods included the use of thematic analysis for analysing qualitative data. A 5-point Likert scale was converted to a 3-point Likert scale to interpret and analyse quantitative data.

Results: The results from the research have shown that there exist several barriers to energy efficiency in South African municipalities. The research classified barriers into three categories, and fourteen theoretical barriers, i.e., (i) technical (with two important barriers), (ii) economic (with four important barriers) and (iii) governance (with eight important barriers). The findings of the study showed that limited access to internal funding for energy efficiency projects was the largest barrier affecting the improvement of energy efficiency in selected municipalities.

Conclusion:

The findings from this study underscore the importance of addressing energy efficiency barriers for the improvement of electricity management in the municipalities. In addition, the importance of the linkages and interaction of barriers was highlighted. A holistic and systematic approach to energy efficiency is important in overcoming the barriers to energy efficiency.

Keywords:

Energy Efficiency Barriers, Electricity Management, Energy Efficiency Demand Side Management, Taxonomy, Municipality

ABBREVIATIONS AND ACRONYMS

DoRA	Division of Revenue Act No.1 of 2010
DoE	Department of Energy
DME	Department of Minerals and Energy
EEDSM	Energy Efficiency Demand-Side Management
ERA	Electricity Regulation Act No.4 of 2006
ESCO	Energy Services Company
HVAC	Heating, ventilation, and air conditioning
IEP	Integrated Energy Plan
IRP	Integrated Resource Plan
ISO	International Organization for Standardisation
LED	Light-emitting diode
MSA	Municipal Systems Act No.32 of 2000
NEA	National Energy Act No.34 of 2008
NEES	National Energy Efficiency Strategy
NEEAP	National Energy Efficiency Action Plan
NERSA	National Energy Regulator of South Africa
NDP	National Development Plan
SANS	South African National Standards
SDG	Sustainable Development Goals
SMEs	Small Medium Enterprises

KEY DEFINITIONS

The barrier to energy efficiency - the *“mechanism that inhibits investment in technologies that energy-efficient and cost-effective for the potential investor in those technologies.”* (Sorrell et al. 2011:4).

Energy Efficiency is a *“measure of the saving of energy used to produce goods and service while maintaining desired benefits”* (ASSAF, 2014:71).

Energy Policy - *“strategy, clearly elaborated and explicitly formulated by the government, to govern the current and future energetic balance.”* (Hogwood and Gun, 1984:107).

Research – *“An activity undertaken to find answers to the questions systematically and logically using data collection such that it increases people’s knowledge.”* (Saunders et al. 2012:5).

Taxonomy – *“A scheme of classification in which things are organised into groups or types”* (Thomson et al. 2018:4).

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CHAPTER 1 INTRODUCTION

1.1 Background

Greening of the electricity sector is one of the key critical responses to the pressing climate change, economic development, and electricity security challenges facing South African municipalities. It refers to the improvement of energy efficiency on both the supply and demand side which lead to reducing greenhouse gas emissions and increasing access to energy through electricity conservation (UNEP, 2015). Improving energy efficiency is one aspect of the greening of the electricity sector. In the context of this research “greening” is an approach for improving energy efficiency in municipalities and it is based on a comprehensive set of activities that must be conducted systematically and include energy intensity, energy efficiency legal framework, energy efficiency policies and programmes and energy efficiency standards (Filippo, 2012).

Energy efficiency has become a term associated with electricity reliability (SEA, 2013:6). Many researchers have accepted that greening the electricity sector through energy efficiency improvement is one of the most cost-effective approaches toward sustainable electricity supply and reduction of the continuously increasing electricity consumption (Shen *et al.* 2012, Zhang *et al.* 2017). To affect electricity reliability, energy efficiency reduces the average monthly electricity consumption (DoE, 2018:13).

Municipalities are mandated to ensure access to reliable electricity and to provide this electricity efficiently (Eberhard, 2011). They can promote energy efficiency in their jurisdictions by developing and implementing strategies that improve the efficiency of municipal facilities and operations by upgrading municipal lighting infrastructure (energy-efficient traffic lights, new light-emitting diode lights (LED) on high masts), municipal building infrastructure (heating, ventilation, and air conditioning (HVAC)), energy-efficient water infrastructure, installation of solar water heaters and energy-efficient wastewater treatment (USAID, 2020:1; DoE, 2019a:2), and/or encourage energy efficiency improvements in residential, commercial, and industrial sectors (World Bank, 2010:5).

Although energy efficiency initiatives have gained traction in South Africa, their uptake in local government has been associated with implementation barriers. Many research studies have found that municipalities are facing challenges in the implementation of energy efficiency (Filippo, 2012, Kruger and Tait, 2015). Barriers may exist in many forms and at different points during the

implementation and management of measures to improve energy efficiency (Singh and Lalk, 2006). The present study confirms the previous findings of Sorrell *et al.* (2000) and contributed to a further understanding of how municipalities can respond proactively to the barriers that affect the energy efficiency improvements.

1.2 Problem statement and rationale for the study

1.2.1 Problem statement

Municipalities have a potentially key role to play in addressing climate change and electricity security in South Africa because they are the level of government closest to where the impacts of climate change and electricity shortages will be felt. Municipalities are the level of government generally most directly responsible for planning and implementing national adaptation strategies (SALGA, 2017).

Energy efficiency initiatives are being implemented throughout South Africa. Although the adoption rate is low among municipalities, those that have started the implementation process have indicated economic benefits (Cullen *et al.* 2012:13050), and improved electricity and water conservation (Covary and Aversch, 2013:595). The low adoption rate is attributed to the existing strains on resources and capacity (DoE, 2015:9). According to OECD/IEA (2010), the contemporary energy efficiency challenges (technical, economic, governance etc.) make it difficult for municipalities to adopt a conscious scientific method in facing these challenges and to invest the active human energies in supporting operational performance.

The South African municipalities face technical challenges of overloaded electrical systems, poor infrastructure, maintenance capacity and constant load shedding. Barriers to energy efficiency can be found in equipment design and supply, diffusion, and operation (SALGA, 2017). When the electrical grid is forced to deliver more power than capacity allows either due to technical failures or persistent power shortages, outages, and unreliable electrical services result (iea-isgan, 2015).

The current problems with Eskom's power stations and the growing electricity demand are expected to further pressure the existing electrical grids (Filipova *et al.* 2019) and this problem will likely worsen. According to (UNIDO, 2006), municipalities are confronted with a lack of qualified personnel with the technical capacity to identify, appraise, develop, and implement

energy efficiency projects and a lack of experienced specialists who can identify barriers and assess their degree of impact (Bilous, 2020:20) and the lack of local procurement of energy efficiency technologies (OECD/EIA, 2010:32).

Most municipalities have not conducted energy surveys and are therefore unaware of the benefits of improved energy efficiency (DoE, 2018:19). The South African Local Government Association (2018:4) indicated that the effectiveness of the deployment of energy efficiency in South African municipalities is still unknown, as municipalities do not have the capacity to conduct technical audits. There is also a lack of reliable data on the amount of electricity saved in all municipalities (DoE, 2016:460).

Market failure contributes to the failure of the successful implementation of energy efficiency (Thollander *et al.* 2013). Lack of information and awareness of the potential for energy efficiency opportunities was cited by Golove and Eto (1996) as a barrier. Lack of consumer awareness and understanding or limited information on the knowledge and benefits of energy efficiency (DoE, 2018:14). Shen *et al.* (2012:21) identified the lack of available and diversified energy efficiency technologies in various municipalities as a market-based barrier.

The low price of electricity in South Africa is one of the significant barriers to the investment in energy efficiency in the country (de la Rue du Can *et al.* 2013:3). High transaction costs, i.e., energy efficiency project development costs are high relative to potential electricity savings (DoE, 2018:15), where the energy efficiency technologies are generally more expensive than traditional energy-intensive technologies (OECD/EIA, 2010:35). Inadequate subsidies for energy efficiency projects (Sorrell *et al.* 2003:11) and lack of finance to continue energy efficiency investment (Aboltins and Blumberga, 2019:197) are also identified as barriers.

While South Africa has several policies, regulations, and initiatives in place to scale up energy efficiency behaviour and technologies, there is a lack of coherence and alignment to facilitate the Implementation of energy efficiency (Covary and Aversch, 2013:592). The purpose of creating coherence and alignment is to identify common goals and connections across seemingly disparate energy efficiency initiatives and take advantage of energy efficiency opportunities to maximize efforts (Kruger and Tait, 2015, Casazza and Chulu, 2016).

Politics are central to local government. Langlois-Bertrand *et al.* (2015:6) pointed to the lack of political will as the most important reason why municipalities are unable to commit to energy efficiency improvements or policies. Most of the scholars who wrote about energy efficiency across municipalities have concluded that there must be a political will to allow the municipalities to reduce high electricity consumption (Filippo, 2012, Kruger and Tait, 2015). Hasanbeigi *et al.* (2010) indicated the lack of top management support and commitment to energy efficiency as a barrier.

Based on the discussion above, the study suggests that the South African municipalities are facing serious barriers to implementing energy efficiency. These barriers do not only affect businesses, communities and investors in local economies but also affect the country's energy efficiency targets (DoE, 1996).

1.2.2 Rationale for the study

The rationale for this study is informed by the research objectives which seek to describe and classify barriers to energy efficiency in specific municipalities. The South African municipalities have the responsibility to make sure that all citizens are provided with services to satisfy their basic needs. They must make sure that the citizens in their areas are provided with reliable electricity (Eberhard, 2011). Municipalities must address electricity service delivery by addressing access to electricity services and stimulating the local economy (SALGA, 2013:7). Municipalities play an important role in reducing the pressure on the electricity grid and are critical in achieving the country's energy efficiency targets (DoE, 1996).

Through their service delivery programmes, municipalities are implementing the Energy Efficiency Demand Side Management (EEDSM) programme which seeks to reduce the electricity generation capacity. The programme become constrained when municipalities don't function well, and communities directly suffer the consequences when basic electricity service delivery is poor. In addition, municipalities form part of the broader architecture of government. They are therefore interdependent on national, provincial and district government functions (Asha and Makalela, 2020).

Many researchers, based on their expertise and experience have examined the barriers to energy efficiency in South African organisations (Sebitosi, 2008; Covary and Aversch, 2013; de la Rue

du Can *et al.* 2013; Fawkes, 2005; Goldberg, 2015; Kohler, 2015; Kruger and Tait, 2015; Singh and Lalk, 2006). Based on the sourced literature review, it has become very clear that this research is one of the few that systematically examines the barriers that affect the implementation of energy efficiency in specific South African municipalities (Local, District and Metropolitan Municipalities). Previous studies only focused on a single municipality. This study is aimed to extend the findings of previous research on this topic.

Describing barriers to energy efficiency is not the only aspect of improving energy efficiency, focus must also be directed on the ability to organise these barriers to ensure the improvement is sustainable. The focus must include, “what” barriers are associated with the implementation of energy efficiency? (Thollander *et al.* 2013) and “how” can these barriers be grouped (Sorrell *et al.* 2003)? The study also attempted to provide a taxonomy that can be used by municipalities. It is worth noting that the literature on barrier taxonomies is rather limited (Nickerson *et al.* 2013:337).

1.3 Research aims and objectives

Creswell (2009:211) indicates that for a research problem statement to be clear, the researcher needs to establish the aim of the study. Considering the recent electricity problems in South Africa, this study aims to support the knowledge and understanding regarding the energy efficiency improvements.

Stemming from the earlier work of Sorrell *et al.* (2000), this study aimed to describe and classify barriers that hinder the improvement of energy efficiency initiatives in specific South African municipalities. Furthermore, the study provided an overview of how municipalities can respond proactively to these barriers in the electricity sector. It is targeted at municipal energy professionals in selected municipalities.

Objective 1: Evaluate the status of energy efficiency initiatives in specific South African municipalities.

Objective 2: Characterise the barriers that hinder energy efficiency by evaluating the implementation of the Energy Efficiency and Demand Side Management programme in selected municipalities.

Objective 3: Identify potential options for addressing the barriers to implementing energy efficiency initiatives.

1.4 Scope of the research

The scope of this study is to add value and knowledge to a research area that seeks to overcome the barriers to energy efficiency. This study is important for a country like South Africa, where the electricity infrastructure has been degrading with scheduled and unscheduled power outages on the increase. To better understand the barriers that affect the successful implementation of energy efficiency in specific South African municipalities, this study collated information from Local Districts and Metropolitans Municipalities. Selected municipalities are situated in the seven provinces across South Africa

1.5 Assumptions and limitations

With the objectives of the study in mind, certain assumptions and limitations are defined. A vast body of literature on the topic of energy efficiency improvement and barriers that prevent the successful implementation exists. However, it is often the perception of those who work in the field of energy efficiency as practitioners that may provide additional and valuable insights on the challenges and solutions for overcoming energy efficiency barriers. Based on the presented activities, the energy professionals employed by my municipalities and energy efficiency experts are placed at the centre of this research.

In this sense, the energy professionals are persons who evaluate electricity use, and design and supervise the implementation of energy efficiency measures (Brunke *et al.* 2014), whereas energy experts are responsible for closing the gap between theory and practice and providing the necessary background and help for decision-makers when they are dealing with energy-related issues (Shi *et al.* 2008). The perception of both the energy professionals and the experts was vitally important to this study as it will unearth the major operational barriers within municipalities.

Following the above assumptions, the study did not investigate the consumer's perceived value due to data access limitations. Perceived value is a consumer's perception of effective electricity services. The exclusion of this discussion is a major limitation of this study as the effectiveness of electricity services is largely based on whether consumers believe it can satisfy their wants and needs as factors like convenience, pricing and reputation can contribute to a consumer's perceived value of a service. Although many interviewees mentioned the consumer perceptions

to some extent, it cannot be seen as a reliable source of data and their understanding is based only on secondary sources and not on their own experiences or observations.

1.6 Structure and outline of the dissertation

This research was based upon the earlier work of Sorrell *et al.* (2000) together with another literature review on the studies of barriers to energy efficiency. The study was conducted over three stages that informed the aim of the research. Stage 1 included a review of the literature presented in Chapter 2. Stage 2 included a sample of municipality participants who will characterise the energy efficiency barriers in specific South African municipalities. The result of this research is presented in Chapter 4. This chapter also included the recommendation. Stage 3 brought together a discussion on the findings from the literature review from Chapter 2 and the results of the empirical study from Chapter 4. The discussion is presented in Chapter 5. This chapter also includes the conclusion of the study.

Table 1-1: Structure and outline of the dissertation

Chapters	Description
Chapter 1	Introduction: Background, problem statement and rationale, research aim and objectives, structure, and outline of the study.
Chapter 2	Methodology: Introduction, research design, data collection, data analysis, ethical consideration, methodological limitation, and chapter summary.
Chapter 3	Literature review: Introduction, theoretical concepts, and empirical literature.
Chapter 4	Results and Data analysis
Chapter 5	Discussion and Conclusions

1.7 Chapter Summary

This chapter outlined the background of the study by firstly presenting the global and national policies of energy efficiency. It further discusses energy efficiency at the local government level. The Chapter presented the problem statement and argued that the implementation of energy efficiency is needed to reduce the high energy intensity. The research's primary aim was to describe and classify barriers to improving energy efficiency in specific South African municipalities.

CHAPTER 2 METHODOLOGY

2.1 Introduction

This chapter presents the research design and research methodology employed in the study. The method selected was important to draw out the essential components that would assist in addressing the research aims and objectives. Notably, this chapter is essential to achieve the ambitions of the primary aim of the study. The chapter begins by describing the research design approach and the research method. The methodology was composed of working processes made of two phases: conduct a review of the literature and conduct primary data collection that included the development of the research questionnaire and interviews.

2.2 Research design

According to Babbie and Mouton (2008:74), a research design is a blueprint to which the researcher conducts the research, whereas Leedy and Ormod (2013:92) described it as the overall structure for the process the research follows. Creswell (2009:3) expressed that it summarises the methods of data collection and analysis. Further description from Kumar (2005:208) described a research design as a general plan of investigation, adopted by the researcher in carrying out a research study and obtaining answers about the research problem.

According to Leedy and Ormod (2013:26), a research method is a general approach taken by the researcher in carrying out the research project. Burién (2010:46-47) explained that this approach involves procedures, processes, and tools to collect and analyse data. The research methods can be divided into qualitative and quantitative research approaches (Babbie and Mouton, 2008; Leedy and Ormod, 2013).

The qualitative research approach aims to gather an in-depth understanding of human behaviour and the reasons governing such behaviour (Creswell and Plano Clark, 2007:6; Creswell, 2003:255; Babbie and Mouton 2008:53) through the review of available literature, engagement in informal discussions with the participants, and the formulation of a formal discussion through the interviews (Teddlie and Tashakkori, 2009:15). Quantitative research gathers descriptive information by examining relationships between variables (Creswell, 2013:4).

According to Creswell (2003), the researcher can choose to use either of these two methods for data collection and analysis, however, if the researcher chooses to use both methods in research, the researcher would have used a mixed-method approach. This research, therefore, employed an exploratory sequential mixed-method approach that uses both qualitative and quantitative research methods for data collection and analysis (Creswell, 2003:264). In this sequential data collection approach, the qualitative data is collected first, and the results inform the quantitative. Thus, the complementary use of qualitative and quantitative approaches provides a wider range of knowledge and insight which improves the overall validity of the results (Creswell, 2008).

Babbie and Mouton (2001:80) explained that exploratory studies are undertaken due to the relatedly new information in the study area. They can be used to define central concepts and construct to get a better understanding of the phenomenon. Saunders *et al.* (2012:13) explained that exploratory research is conducted to determine the nature of the problem and does not intend to offer a conclusive solution to the problem, but rather helps the researcher to have a better understanding of the problem.

Because a study on the barriers to energy efficiency has not yet been developed for South African municipalities that included Local, District and Metropolitan, this research employed an exploratory research method (Babbie and Mouton, 2001:80). The roadmap of the research is presented in Table 2-1. This table links the research objectives and the research methodology.

Table 2-1: Summary of the Research Roadmap Matrix

Research Objectives	Data Collection Methods	Data Analysis and Presentation
Objective 1: Evaluate the status of energy efficiency in specific South African municipalities.	Secondary Data (Literature review): Stage 1 involved a review of literature that surveyed existing taxonomies to find out how they could inform a 'study of barriers to energy efficiency in specific South African municipalities. Resources used for the systematic literature review included national policies and legislation on energy efficiency, peer-reviewed scientific journals related to municipal energy efficiency, academic books on research methods and documents from	A Microsoft Excel spreadsheet was used to capture and analyse the literature review data by coding and tracking themes in qualitative data (Leedy and Ormod, 2013:372). The data were cleaned (coded) to remove any overlapping and duplicate entries (USGAO, 2013: A5-1).

Research Objectives	Data Collection Methods	Data Analysis and Presentation
	municipal energy efficiency projects, as well as international recommendations/guidelines on energy efficiency. These documents were used to build the background of the study research (Bowen, 2009:31), design the research objectives (Creswell and Tashakkori., 2007:210) and build a conceptual framework (Burian, 2010:57).	A rating scale method was used to quantify data from the interview questionnaire (Kuo and Hoag, 2016:2). A 5-point Likert scale was condensed to a 3-point Likert scale to assist in the evaluation and analysis of quantitative data.
Objective 2: Characterise the barriers that hinder energy efficiency by evaluating the implementation of the EEDSM programme.	Primary Data Stage 2 was the identification of municipality participants to validate the results of the literature. A semi-structured interview questionnaire collected both the qualitative and quantitative data (Creswell, 2013:81, Filippo, 2012:44). The questionnaire contained open-ended and closed-ended questions. The open-ended questions required the participants to answer basic questions on energy efficiency (Babbie 1992:147; Babbie, 2014:509), whereas the closed-ended questions required participants to rank the predetermined barriers (Polit and Beck, 2010:38). Using a 5-point Likert scale, the study collected quantitative data (Joshi and Pal, 2015:398). A pilot test was conducted with a small group of representatives to assess the validity and primary clarity of the questionnaires (Rowley, 2014:13). The experts evaluated whether the interview questionnaires effectively captured the topic under investigation (Aithal and Aithal, 2020:6). An interview questionnaire was sent to one known Local Municipality official and one expert to test the proposed research study objectives, the time to complete the questionnaire, and the study design (Foddy, 2003).	The survey results were presented in tables and diagrams.

Research Objectives	Data Collection Methods	Data Analysis and Presentation
	The interview questionnaire was sent to the respondents through emails. The semi-structured interviews were used to collect missing data from the interview questionnaire (Green <i>et al.</i> 2015:512). The interviews were conducted using Microsoft Teams and cell phones.	
Objective 3: Identify potential options for addressing the barriers.	Primary and Secondary Data Stage 3 brought together the findings from Stage 1 and Stage 2 to describe the barriers affecting specific municipalities and how they can overcome these barriers. The findings from the systematic literature were used to provide recommendations on opportunities to potentially overcome the barriers to implementing energy efficiency practices. The literature was reviewed to identify recommendations on how to overcome the energy efficiency barriers. These recommendations were included in Chapter 4 of the dissertation. Respondents: In addition to the opportunities identified in the literature review, recommendations from the municipal respondents and the experts offered opportunities to overcome the barriers. These data were collated and summarised in Chapter 4.	

2.3 Data collection

Data collection methods are the tools that a researcher follows to gather the primary and secondary information to answer the research question (Cooper and Schindler, 2008:12). The primary data collection method included the use of interviews, whereas the secondary data collection method included a survey of the existing literature on the barriers to energy efficiency. According to Adams *et al.* (2007), the selection and collection of primary and secondary data play an important role in achieving the research objectives.

2.3.1 Secondary Data Collection

Secondary data on energy efficiency barriers were collected from the literature that included scientific peer-reviewed journal articles, internet resources, books, and government publications (Babbie and Mouton 2001:79; Creswell 2002:260). To develop a comprehensive database of energy efficiency studies, several inclusion and exclusion criteria were used. The inclusion criteria included articles published in electronic academic journals, websites of government departments and agencies and books. The researcher conducted full-text searches for the term 'barrier' and 'energy efficiency in the identified literature review.

Systematic reviews aimed to identify all studies that are relevant to the research objectives and to synthesize data about the design and risk of bias. Basic research textbooks intended for theoretical research methodologies were used. Applied research textbooks on energy efficiency were used. Peer-reviewed scientific journals were extracted from the internet using a desktop literature search. Journal articles were the major data source included in the systematic review. Basic keywords were used in the search engine. The papers were written in English. The search included literature that was published from the early 1990s to 2021. Duplicate articles, articles not written in English and studies available only as abstracts were excluded from the search.

Two hundred and fifty articles which showed a connection between energy efficiency and barriers to implementation were found. Initially, the articles were analysed to identify significant studies related to the proposed aim. The first selection phase was done on study titles. Any article that had the potential to be included was selected for the abstract. By means of specific inclusion and exclusion criteria one hundred and eighty-two articles were selected for final analysis. The methodology observed in this study including systematic literature review, structure and steps of the screening process is described in Figure 2-1.

A systematic literature review of existing taxonomies of barriers to energy efficiency was conducted using an extensive guide to systematic literature reviews (Tranfield *et al.* 2003), which informed the planning and scoping stages of the study. Systematic reviews were conducted on empirical studies, rather than individual reports, so multiple reports of the same study were identified and linked together for data extraction.

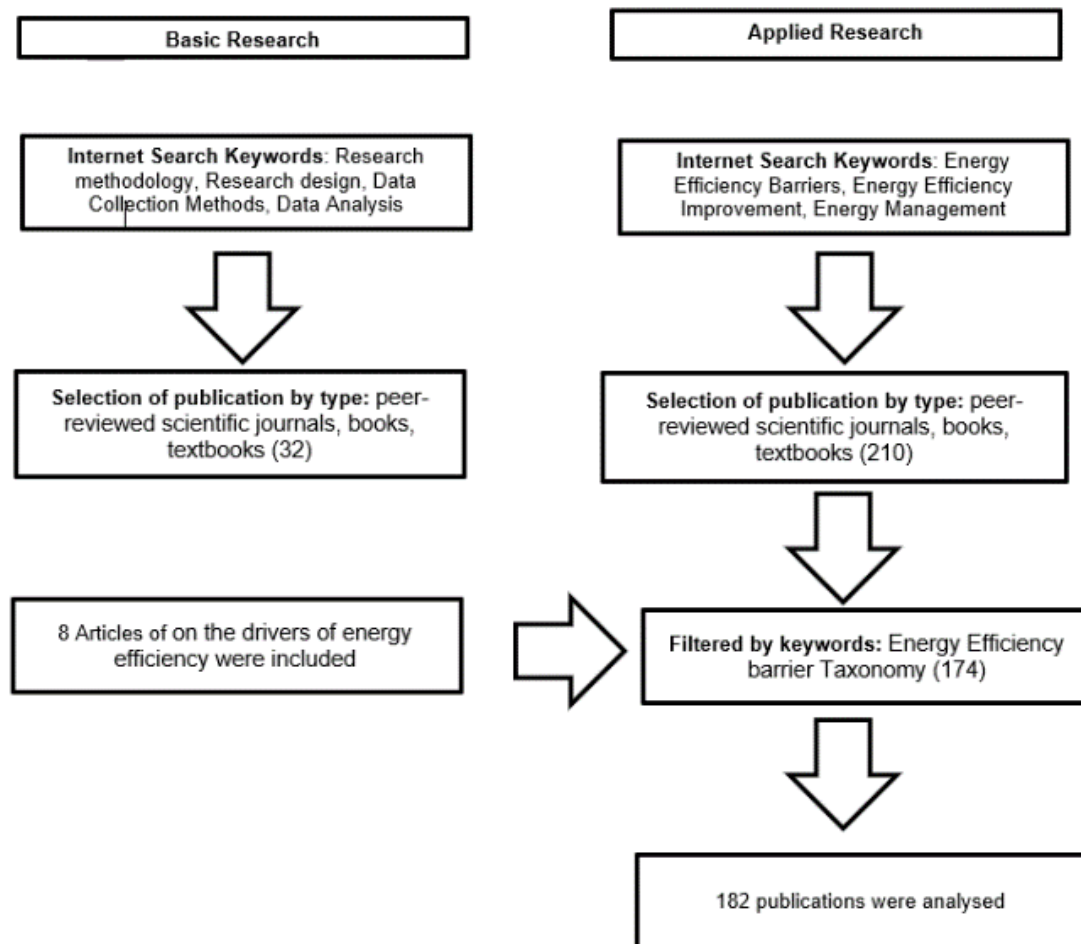


Figure 2-1: Summary of systematic literature review

2.3.2 Primary Data Collection

2.3.2.1 Sampling Size

Etikan *et al.* (2016:1) described a sample as a subset of a population selected to participate in a research study to understand the population. Babbie and Mouton's (2001:287) guidelines stated that "a general rule of thumb indication for South African master's level of study is between five and twenty-five respondents". Depending on the type and objective of the study, the number of participants will differ. In statistical analyses for example, a larger sample is used to improve the power of testing, i.e., their ability to detect significant results.

According to Cherry (2000:54), a small representative sample is important when the scope of the research is to describe a phenomenon rather than to find representative data. This is referred to as the phenomenological approach to qualitative research.

Twenty-two municipality respondents and four experts agreed to participate in the research. The sample included sixteen Local Municipalities, four District Municipalities and four Metropolitan Municipalities. Seven of the municipalities were from the Western Cape, five from the Eastern Cape, three from KwaZulu-Natal, three from Gauteng, two from North-West, one from Limpopo and one from Mpumalanga.

Eight experts were initially identified as key informants who can inform the research through their knowledge, experience, and expertise. However, only four experts responded positively and were readily available to participate in the study and willing to share their knowledge on the subject. The twenty-two municipal participants and four experts, which participated in the research, fall within the guidelines of Babbie and Mouton (2001). Because the research did not analyse data statistically, and the guidelines of Babbie and Mouton (2001) were applied.

2.3.2.2 Sampling Methods

A purposive sampling technique was important for this kind of study (Babbie and Mouton, 2011:166). Purposive sampling involves selecting a target sample of the population that are subject experts and knowledgeable about the research topic (Ames *et al.* 2019). This sampling method is most practical when the total population is of a manageable size (Etikan *et al.* 2016).

The targeted focus group included energy practitioners from twenty-two municipalities that had similar professional categories and a particular set of characteristics, e.g., they had relevant experience in energy efficiency, knowledgeable on energy policies, are implementing energy efficiency demand-side management, and are in senior positions (Aithal and Aithal, 2020:3). Using a purposive sampling method of the target population, the respondents were selected by firstly conducting a search on the internet through a search engine (Google) to establish a list of municipalities and their locations, (Ames *et al.* 2019).

Snowball sampling was used to gather additional respondents from the municipalities by requesting the participants to pass along the questionnaires to their colleagues who have experience with energy efficiency. This method was important to recruit one municipal official that was unknown to the researcher (Filippo, 2012:46).

Expert sampling was used to elicit the views of energy experts that have specific experience or expertise within the field of energy efficiency. Expert sampling is a form of purposive sampling that seek the views of the experts on a certain matter. The experts were recruited to comment on the validity and reliability of the responses received from municipal officials (Aithal and Aithal, 2020:6).

The research targeted highly skilled officials and senior-level management, which included eleven Senior Managers, three Executive Directors, three Technical Directors, four Electrical Engineers and one intern engineer. Although not a senior official, an intern who had three years of experience working in energy efficiency was included in the sample. To ensure anonymity and ethical consideration, the respondents were assigned a number, while retaining the specific identification of respondents (See Annexure A for a list of respondents).

2.3.2.3 Development of the interview questionnaire

The interview questionnaire designed presented in Table 2-2 followed the guidelines presented by various authors (see Babbie and Mouton, 2007; Babbie, 2014; Aithal and Aithal, 2020) where they indicated that the questionnaire should be short, simple, and unambiguous. The literature of Sorrell *et al.* (2000, 2003, 2004) was further used to develop interview questions.

Primary data collection followed two phases. The first phase included the use of a self-administered interview questionnaire. The interview questionnaire included open-ended (Babbie 1992:147; Babbie, 2014:509) and closed-ended questions, e.g., the Likert scale (Polit and Beck, 2010:38). The questionnaire that contained both qualitative and quantitative data was structured and distributed to the participants. Using the framework originally developed by Sorrell *et al.* (2000), the interview contained questions on the important barriers to energy efficiency. It also included the drivers for the improvement of energy efficiency (see Annexure C).

The questionnaire was divided into three parts. **Section A** of the questionnaire provided the aim and the overview of the research. In addition, this part included the demographic analysis of the participants (Aithal and Aithal, 2020:3). Demographic analysis was used to develop an understanding of the composition of a population (Isotalo, 2009:5). In this study, demographic information of the participants included the level of education, job status and work experience.

Bernard (1988:440) indicate that there is a positive relationship between education, experience, and practices of people.

Section B of the questionnaire contained questions about respondents' general knowledge and awareness of energy efficiency policies and targets, the relationship between energy efficiency and energy demand, and energy efficiency practices in the municipalities.

Section C of the questionnaire applied the 5-point Likert scale to extract information on the barriers to energy efficiency in municipalities (Joshi and Pal, 2015:398; Aithal and Aithal, 2020:5). The administration of the questionnaire was conducted by firstly requesting permission from the Municipal Managers to start the data collection within municipalities. During the formulation of the questionnaire, the following factors were taken into consideration:

Table 2-2: Interview Questionnaire Design

Item	Description
Type of questions/statements	The questions/statements were semi-structured. Thirty-three questionnaires were developed for the three barrier categories that needed to be explored on which themes were developed. The open-ended questions allowed the respondents to define and describe events in their municipalities (Babbie, 2014:509).
Length of questions/statement	The length of the question/statement has a negative impact on the quality of responses. The shorter and more precise the question/statement, the better the results (Babbie and Mouton, 2007:89).
Accuracy	The questions/statements were designed in such a way that they would reduce errors. The use of pilot testing and experts were used to identify items that were ambiguous or unclear to the respondents, identify language errors and inaccuracies of the questionnaire, and give an indication of the nature of responses and subsequent data analysis (Aithal and Aithal, 2020:6).

2.3.2.4 Development of the 5-point Likert scale

The third part of the interview questionnaire consisted of questions answered using a five-point Likert scale. A Likert scale questionnaire was the main instrument for providing quantitative data.

According to Sekaran and Bougie (2011:155), a Likert scale is a rating scale used to evaluate various attitudes, behaviours, and opinions in organisational research. The Likert scale enabled the researcher to gain an understanding of the respondent's views on the barriers to energy efficiency. When choosing the type of Likert scale to use, Joshi and Pal (2015:399) indicate that a 5-point Likert scale is the most practical, easy to respond to and straightforward to analyse.

Clear instructions were provided at the beginning of the questionnaire on how to answer the question. Respondents answered the questions by placing an "X" in the box which best describes their response to the question. The box contained numerical values, where "1" = the barrier has an extremely low impact on the implementation of energy efficiency initiatives; "2" = the barrier has a low impact on the implementation of energy efficiency initiatives; "3" = the barrier has a moderate impact on the implementation of energy efficiency initiatives; "4" = the barrier has a high impact on the implementation of energy efficiency initiatives and "5" = the barrier has an extremely high impact on the implementation of energy efficiency initiatives.

2.3.2.5 Interview Schedule

The secondary phase of primary data collection included follow-up interviews with the respondents, which were conducted to fill the gaps in the interview questionnaire, provide clarity on questions, and extract further qualitative data (Dunn, 2005 in Hay, 2005:112). According to Babbie and Mouton (2001: 270-292), an interview is important to prompt the information concerning respondents' perception and understanding of the subject matter. The semi-structured interviews were used to clarify vague statements to the respondents and sought to explore the topic by allowing respondents to provide more details. The interviews were carried out telephonically and through the social medial platform (Microsoft Teams). The expert respondents were also interviewed. A Notebook was used to capture and store information during the interviews and the information was transferred to Microsoft Excel Spreadsheet.

2.4 Data analysis

Once the process of data collection has been completed Leedy and Ormod (2011) postulate that the researcher should begin the process of data analysis to detect patterns within the data. Data analysis included three elements, namely (i) coding and data entry, (iii) editing data and (iii) data transfer from Excel Spreadsheet to Word (Sekaran and Bougie, 2013:280). Snyder (2019:230)

pointed out that data analysis is used to reduce and organise data to produce results that require interpretation by the researcher.

The primary purpose of data analysis is twofold: first, to find patterns within the data to support or disprove the research objectives through qualitative methods (Filippo, 2012:53) and second, the reduction and organisation data collection through quantitative methods (Gray *et al.* 2017:110). In this manner, the data collected through the 5-point Likert scale was reduced to the 3-point Likert scale. An inductive approach to data analysis was used (Braun and Clarke, 2006). In this research, inductive analysis refers to the use of raw data to identify themes, patterns, and relationships among variables (Creswell, 2002:266).

2.4.1 Qualitative Data Analysis

Creswell (2013) outlines three steps needed to be followed in qualitative data analysis. The first steps require the researcher to read data from various literature to gain a general sense of the information. The second step involves organising and preparing data for analysis. The third step involves coding the data by categorising the text and images and labelling the categories. The first step was conducted during the data collection phase and is presented in Chapter 3. Figure 2-2 provides the results of the thematic analysis.

2.4.2 Quantitative Data Analysis

Descriptive tools were used in the analysis of quantitative data. Mouton (2001:54) and Leedy and Ormod (2011:191) generally describe the descriptive approach as a method of organising and summarising data to render it more comprehensive in describing trends in the data and relationships between variables.

Descriptive analysis was used to provide demographic information about the participants, it consists of variables such as job status, experience, and education (Isotalo, 2009:5). Univariate analysis was used to analyse the barriers in the self-administered questionnaire and interviews to describe patterns and detect relationships between variables (Bryman, 2008:699). For this study, the researcher used calculations of frequencies and percentages expressed as tables, charts, and graphs as tools for descriptive analysis. Chapter 4 provides a discussion of the findings.

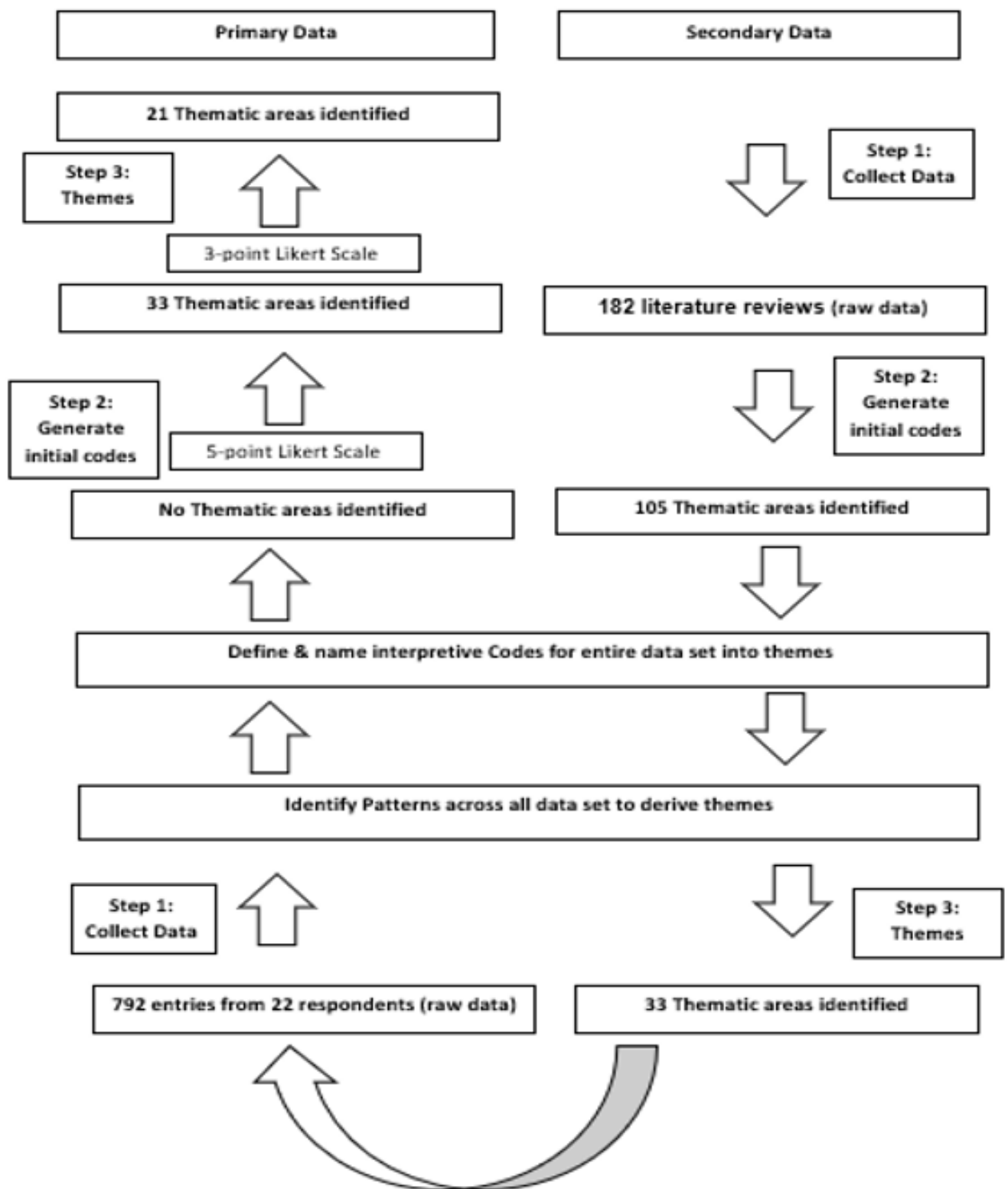


Figure 2-2: Thematic Analysis

Adapted from Braun and Clarke (2006) and Creswell (2013)

2.4.2.1 Conversion of the 5-point Likert Scale to a 3-point Likert Scale

To better analyse and present the results, the 5-point Likert scale was converted into a 3-point Likert scale (Sebakaki, 2017:38). The values “1 - Extremely Low” and “2 - Low” on the 5-Likert scale were combined to form a Low barrier category on the 3-point Likert scale. The values “4 - High” and “5 - Extremely High” on the 5-point Likert scale were combined to form a High barrier category on the 3-point Likert scale. The value “3 - Moderately” remained unchanged, thus forming a 3-point Likert scale (see Figure 2-3).

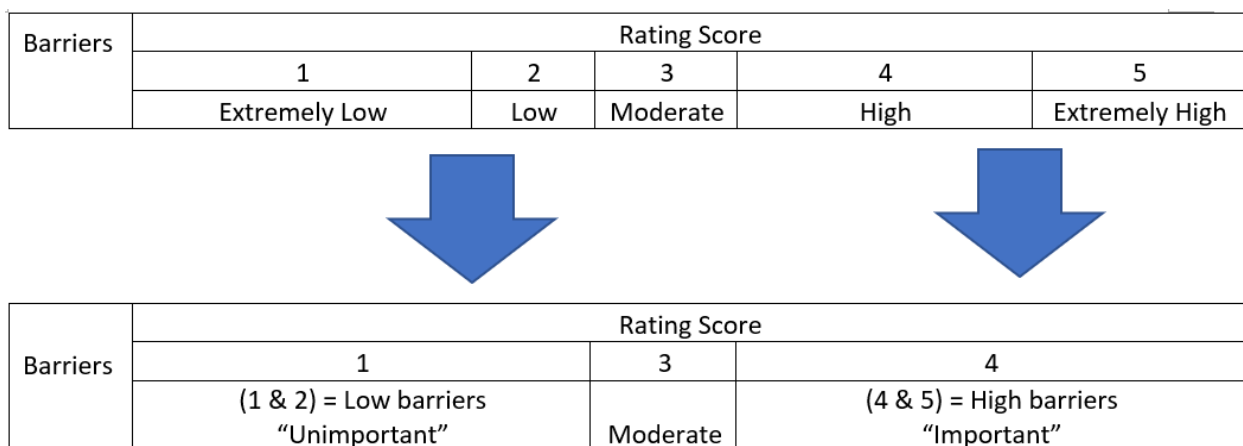


Figure 2-3: Conversion of 5-point Likert scale to 3-point Likert scale

2.4.2.2 Description of the important and unimportant barriers

The research differentiates between important barriers and unimportant barriers (Lam *et al.* 2007; Chan, 2003). Using the 3-point Likert scale, the barriers were categorised as either important or unimportant. Important barriers were those rated as High (4&5), i.e., having a high impact on the implementation of energy efficiency initiatives. Unimportant barriers were those rated as Low (1&2), i.e., having a low impact on the implementation of energy efficiency initiatives. Important barriers are therefore primarily rated as ‘High’, while the unimportant barriers are primarily rated as ‘Low’ on the 3-point Likert scale.

2.5 Ethical considerations

Parveen and Showkat (2017:1) defined ethics as “*the moral principles that govern a person's behaviour*”, i.e., doing what is morally and legally right in research. Creswell (2003:130) indicates that the researcher must respect the respondents' rights, needs, values, and desires. This

research followed the ethical guidelines as suggested by Farrimond (2017) presented in Table 2-3.

Table 2-3: Ethical issues considered in the study

Criteria	Description	Task
Researcher's obligation	Researchers must ensure that their research is conducted with honesty, objectivity, and integrity.	The researcher completed a series of online ethics modules recommended by the North-West University to ensure compliance with ethical standards. The research proposal was approved by the university's Natural Sciences Research Ethics Committee. The researcher was required to sign the confidentiality document to ensure that all the participants' names are kept confidential (Babbie and Mouton 2001: 523). No financial or any other compensation was given to the respondents. The researcher submitted a letter of request to the organisations that participated in this study.
Participant's Right	Participants have the exclusive right to give consent to participate, withdraw from, or refuse to participate in the research projects.	Permission to interview the participants was received from the municipal managers. The respondents were provided with an opportunity to withdraw from the research whenever they wanted to. No participant withdrew or refused to participate in the research once they were contacted and requested to participate.
Transparency	The researcher must reveal all the risks associated with the research to the participants.	The researcher explained the aims of the research to the potential participants on the day of the first participation invitation and during the interview.
Privacy /Anonymity /Confidentiality	No violation of / anonymity/confidentiality.	Consent was requested from the participants and all the participants were informed of their rights to confidentiality and anonymity. The participants were informed that their involvement in the study was purely voluntary, and their anonymity would always be protected. Participants were given to fill out an information sheet and a consent form. Both documents provided the participants with detailed information on their rights to voluntary participation, anonymity, and confidentiality of information.
Data collection	Participants must be given an option of accepting or rejecting data collection devices such as tape recorders, camcorders, etc.	The participants were informed of the use of the tape recorder. The recording device was not used as the participants declined the use of a recording device.

2.6 Methodological assumptions and limitations

Questionnaires and interviews are accompanied by several limitations. Sampling error and systematic bias can be minimised by a thorough selection of respondents, the design of the questionnaire, and data analysis (Gorard, 2003:252).

Table 2-4: Limitations of the research

Research Methods	Limitation
Sample Selection	A small sample size affects the reliability of the result and may lead to higher variability, which may lead to bias (Creswell, 2003:270). To address this limitation, the study sought experts who were more knowledgeable about energy efficiency barriers.
	Purposive sampling is highly prone to researcher bias because a sample relies on the judgement of the researcher and the personal interpretation of the data (Babbie and Mouton, 2008:23; Babbie and Mouton 2001:166-167). To minimise the risk, a conceptual framework was developed to structure and support the justification of the study, the approach problem, the purpose, and the research questions (Bryman, 2012).
	It's difficult when using convenient sampling to generalise findings due to the small samples and content specificity (Miles and Huberman, 1994:25). The results can be considered indicative but not definitive (Irina-Maria and Isaic-Maniu, 2013:170) Although we cannot generalise from the findings of data collected, researchers can surely learn from them (Etikan <i>et al.</i> (2016:4).
Data Collection and Analysis Methods	One limitation of expert sampling is that anyone can purport to be an expert and their opinions might simply be incorrect (Miles and Huberman, 1994:30). To minimise this risk, the study included 4 known experts in the field of energy efficiency. According to Gorard (2003:230), a thorough selection of expert participants can minimise sampling errors and systematic bias.
	Primary data is very expensive and time-consuming compared to secondary data and usually requires a big sample size to be accurate (Sreejesh <i>et al.</i> 2014:143). To help in reducing costs and save time when collecting data, the following methods were undertaken: Word interview questionnaires are inexpensive to produce and were used instead of online interview questionnaires Whatsapp calls were used instead of the expensive traditional phone calls. Online interviews through Microsoft Teams were used instead of Face-to-Face interviews due to Covid 19 pandemic.
	Likert scales are always accompanied by bias (Pratt, 2007:488). To minimise bias, negative attitude options were placed on the left side of the scale and positive attitude options were placed on the right side of the scale (Joshi and Pal, 2015:400).
	The lack of a literature review on the barriers to energy efficiency in the South African context was a limitation as the researcher could not compare results. However, the research employed the views of the experts, who helped in closing this gap.

Research Methods	Limitation
	A literature review has the potential to create a subjective bias (Creswell, 2003:43). To minimise this risk, the research relied mostly on peer-reviewed publications (Creswell, 2014:143).

2.7 Chapter summary

This chapter presented the research design and methodical approaches that were used in the study. Based on the qualitative and quantitative approach to research this chapter followed the exploratory sequential mixed-method approach and reviewed the research design used as well as the data collection instrument. The study collected both primary and secondary data. An interview questionnaire was used as a method of primary data collection whereas a literature review was used for secondary data collection. An inductive approach was used for data analysis.

The population in the study as well as the sampling procedure were explained in detail. The chapter concludes by stating several assumptions and limitations. This chapter is important as it presents the data systematically and logically. Figure 2-4 presents the chapter summary for this study.

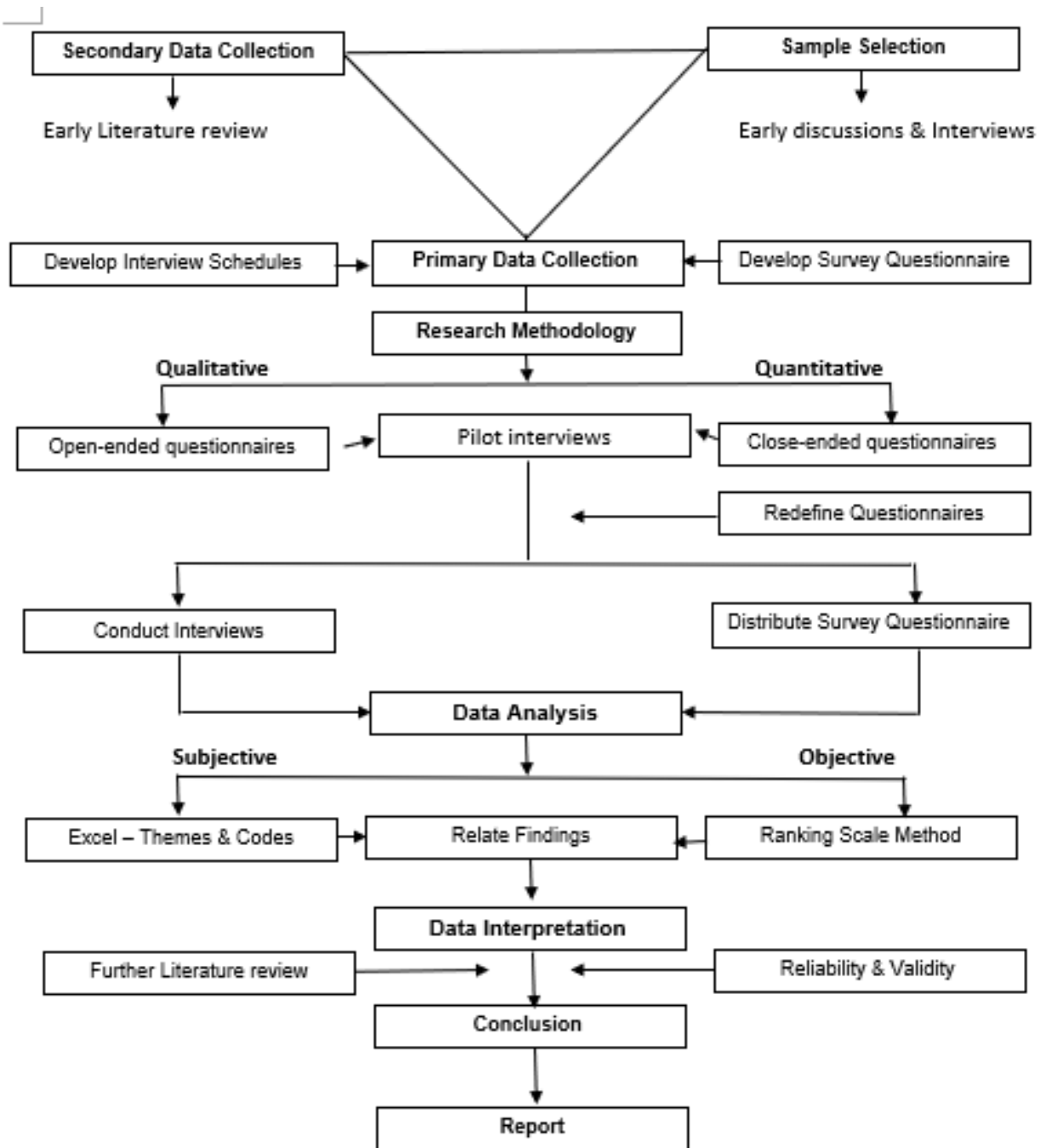


Figure 2-4: Summary of the exploratory sequential mixed method research design
Source: Adapted from Creswell (2003:270).

CHAPTER 3 LITERATURE REVIEW

3.1 Introduction

This chapter presents theoretical perspectives on barriers to energy efficiency practices as identified in the scientific literature. The purpose of the literature review is to identify gaps within the energy efficiency sector (Creswell and Creswell, 2018:34). The review was undertaken to gain an understanding of the various barriers to energy efficiency initiatives. This chapter presents a summary of a literature review in three parts:

Part A – presents the narrative literature review on the practice of energy efficiency in South Africa. This section serves to achieve the ambitions of objective 1 of the study, which is to evaluate the status of energy efficiency initiatives in specific South African municipalities.

Part B – presents some empirical literature relevant to the study. Studies are presented to further understand the barriers to energy efficiency. This section serves to achieve the aspiration of objective 2, which is to characterise the barriers that hinder energy efficiency by evaluating the implementation of the EEDSM in selected municipalities.

Part C – presents the conceptual framework of the study based on Parts A and B above.

3.2 Part A - Narrative Literature Review

3.2.1 Definition of Energy Efficiency

Energy efficiency is a complex concept that is represented in diverse fields. It is for this reason that energy efficiency should be clearly defined. The definition of energy efficiency can prove to be a difficult task especially if one thinks about the various contexts within which the concept can be used. In the South African landscape, energy efficiency is not explicitly defined.

The National Energy Act No.34 of 2008 (NEA) defined energy efficiency as the “*economical and efficient production and utilisation of an energy carrier or resource*” (South Africa, 2008:5). The Integrated Resource Plan provides that energy efficiency is the “*effective use of energy to produce a given output (in a production environment) or service (from a consumer point of view), i.e., a*

more energy-efficient technology produces the same service or output with less energy input” (DMR, 2019:6).

SANS/ISO 50001:2011 standard defined it as the *“ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy”* (SABS, 2011). The National Energy Regulator defined it as the *“overall reduction in energy use by end-users through the use of energy-efficient technologies and retrofits, resulting in the reduction in electricity consumption”* (South Africa, 2004:8), whereas the Department of Energy (2018:1) adopted the definition by the United Nations Industrial Development Organisation (2006) which stated that energy efficiency is *“a measure of how efficiently an appliance, building, organisation or country utilises its energy resources.”*

The National Energy Efficiency Strategy provided two varying definitions, the first is that it is *“the ratio between the theoretical minimum energy requirement for performing a task and the amount of energy used”* The second definition is *“the amount of useful output obtained divided by the energy used to produce that output.”* (DoE, 2016b:8). The latter definition is widely used in the literature (e.g., Sorrell *et al.* 2011:2).

The ambiguity and inconsistent definition of energy efficiency has the potential to create serious implementation challenges and create uncertainty, as it is open to over one interpretation. These various definitions of energy efficiency demonstrate a lack of a generally accepted definition of the concept. Perz-Lombard *et al.* (2009) submit that energy efficiency should be defined according to a particular context. This research adopts a definition by the Academy of Science South Africa, where energy efficiency is defined as the *“measure of the saving of energy used to produce goods and service while maintaining desired benefits”* (ASSAF, 2014:71).

3.2.2 Electricity crisis in South Africa

The South African electricity industry is vertically integrated, with Eskom generating 92.8% of the electricity, while Independent Power Producers and municipalities generate only 7.2% (DoE, 2016a:45). Eskom is the only transmission licensee responsible for transmitting electricity, whereas the responsibility for distribution is shared between Eskom and the municipalities (de la Rue du Can *et al.* 2013:13).

Blackouts have become more frequent in industrial countries due to network deficiencies and continuous load growth (Faranda *et al.* 2007:2086). South Africa is no stranger to this phenomenon. In 2007, the country ran into serious electricity supply constraints when the electricity demand outpaced the rate of electricity supply. As a result, the country experienced repeated power outages continuing into the first quarter of 2008 (iea-igsaw, 2015; Goldberg, 2015, 1). Since then, the ability to supply electricity has remained a challenge. Terms like 'rolling blackouts', 'power outages' and 'load shedding' have become synonymous (UCT, 2013:3).

Much of the blame for these events can be laid on Eskom (Filipova *et al.* 2019:14), as it ignored serious warnings that have affected the electricity supply in South Africa. The 1998 White Paper on Energy Policy warned that the electricity demand will exceed generation capacity by 2007 (South Africa, 1998:41). In the last months of 2007, a national crisis developed when the overall demand exceeded Eskom's generation capacity, mainly due to the shortage of coal supply and coal quality issues, ageing infrastructure, and lack of power station maintenance (IDC, 2015:4). Although the 1998 White Paper on Energy Policy gave serious warnings that Eskom's generation capacity surplus will be fully utilised by 2007 (South Africa, 1998:53), steps were never taken to ensure that the demand does not exceed available supply capacity.

For these reasons, South Africa is now confronted with four critical components of electricity problems. At a national level, the Department of Minerals and Energy (2008:14) identifies three critical problems including capacity, supply, and reserve margin. Altman *et al.* (2008:14), point to the problem brought by Eskom's capacity as caused by the difference between operational generating capacity and the peak demand, meaning, that the installed capacity is insufficient to meet the increasing electricity demands (World Bank, 2010:2).

Recent electricity blackouts are also due to unprecedented breakdowns, failures in generation plants, problems in procurement strategies, and litigations (Newbery and Eberhard, 2007:5). At a local government level, the distribution of electricity by municipalities is the fourth component of South African electricity problems. Generally, the distribution of electricity is poor and is expected to deteriorate even further at great economic costs (Newbery and Eberhard, 2007:6).

3.2.3 The implementation of energy efficiency in South African

3.2.3.1 The benefits of adopting energy efficiency

Given the current electricity crisis in South Africa, it is becoming increasingly difficult to ignore the potential benefits of energy efficiency. The adoption of energy efficiency can have great benefits for municipalities. Extensive research has been conducted regarding the use and the benefits of energy efficiency and these studies have shown that organisations have benefited from energy efficiency implementation. Different researchers use different indicators to measure the benefits of adopting energy efficiency, the most common indicators are the environmental and economic benefits.

Energy efficiency initiatives have been hailed as a good national strategy with many benefits in addressing the country's climate change and energy security challenges. Whether by reducing carbon emissions or increasing energy security, energy efficiency can bring about significant energy savings (Oikonomou *et al.* 2009: 4787). A study by Covary and Aweresch (2013) has indicated that energy efficiency initiatives in municipalities have led to a vast improvement in water conservation. For example, installing energy-efficient appliances in an office kitchen to reduce energy costs can help to reduce water utility bills and decrease the amount of used water that enters the wastewater system.

Energy efficiency upgrades can improve occupant health by enhancing indoor air quality. According to Aboltins and Blumberga (2019:201), energy efficiency creates healthy indoor living environments with healthy air temperatures, humidity levels, noise levels and improved air quality. Installing energy recovery ventilation equipment, e.g., can reduce the infiltration of air contaminants from outdoors while significantly reducing heating, ventilation, and air conditioning (HVAC) energy loads (Minetto *et al.* 2018:420). Enhanced indoor air quality, along with well-designed lighting, greater use of daylighting, and comfortable heating, cooling, and ventilation, can improve employee comfort and reduce fatigue, accidents, absenteeism, turnover, and health costs (Pauliuk and Heeren, 2021:480).

Energy efficiency has been touted as one of the initiatives that can alleviate the pressure from the electricity grid with the potential of reducing emissions associated with electricity generation and decreasing the cost of electricity services (Asha and Makalela, 2020). Energy efficiency

initiatives are frequently deployed through government programmes with the specific goals of reducing peak demand (SEA, 2013:6) and increasing electricity reliability (DoE, 2018:13). Therefore, energy efficiency in municipalities leads to a vast improvement in electricity conservation.

Significant cost savings can be achieved by improving energy efficiency in existing buildings, leasing energy-efficient buildings, and designing new buildings to be energy efficient. Improving energy efficiency in municipal operations such as drinking water systems and wastewater treatment plants represents another opportunity for large cost savings (Sebitosi, 2008:1591, lea- isgan, 2015). Increasing energy efficiency could have significant impacts on income streams for municipalities but could also provide the potential for reduction in operating costs and is critical for local economies to remain efficient and competitive in a changing global environment.

Several studies reported that energy efficiency reduces the need to add expensive new power generation or transmission and distribution capacity by reducing the pressure on electricity resources (South Africa, 2012:48), and increases the available bandwidth in the existing generation, transmission, and distribution networks (Eberhard, 2011), reduces electricity use (DoE, 2018:18), increases electricity reliability (DoE, 2018:13), reduces maintenance cost (SACN, 2014:20-24), stabilise electricity prices and volatility (Padachi, 2014:44), leads to increased employment (Crijns-Graus *et al.* 2020), reduces the amount of electricity needed to deliver services, such as mobility, lighting, heating, and cooling, and enhances productivity and delivers cost savings leading to economic benefits (Sebitosi, 2008:1591). Investing in energy efficiency can stimulate the local economy and encourage the development of energy efficiency service markets (Aboltins and Blumberga, 2019).

3.2.3.2 Drivers of energy efficiency

The drivers for the improvement of energy efficiency have not yet been fully explored (Jalo *et al.* 2021:5). The concept of 'drivers' is found in the discussions of energy efficiency (e.g., Reddy, 2007; Singh and Lalk, 2006), but resist a fixed definition. Sorrell, *et al.* (2004:28) described drivers as the factors that promote energy efficiency Implementation. Cagno and Trianni (2013) defined drivers as "*factors facilitating the adoption of both energy-efficient technologies and practices, thus going beyond the view of investments and including the promotion of an energy-efficient*

culture and awareness.” For this study, the word ‘driver’ refers to factors that motivate the uptake of energy efficiency initiatives to reduce the environmental impact of climate change.

Singh and Lalk, (2006:294) suggested that, for the researcher to categorise the barriers to energy efficiency, the researcher needs to understand the drivers. In other words, every factor that facilitates the adoption, implementation, and feasibility of energy efficiency initiatives and/or reduces the risk of energy efficiency improvement can be considered a driver (Shen *et al.* 2012).

Thollander and Ottosson (2008) identified barriers and drivers for investing in energy-efficient technology in the Swedish pulp and paper industry. The authors divided empirical drivers of energy efficiency into market-related, behavioural, and organizational drivers. Reddy (2013) followed the hierarchy level described by Thollander *et al.* (2010) when examining the drivers and barriers that affect energy efficiency investment. The study was based on a literature review. Longarela-Ares *et al.* (2020) provided a useful categorisation of drivers for organisations engaging with sustainable development: economic (the bottom line), regulatory compliance (do it or break the law) and moral hazard (you should do it).

Few authors have attempted to categorise the drivers of the improvement of energy efficiency, e.g., Thollander and Ottosson (2008) divided the empirical drivers of energy efficiency into policy instruments, market-related, organisational, and behavioural, while Thollander *et al.* (2013) categorised drivers of energy efficiency into organisational, external, and informational. Lane *et al.* categorised drivers of energy efficiency into environmental and financial, whilst Triannia *et al.* (2017) categorised the drivers into economic, informative, and vocational training.

In general, economic considerations are a key driver in the adoption of energy efficiency. These considerations range from potential cost savings, rising energy prices, the availability of public financing, and the reduction in the cost of energy-efficient technology (Sorrell, 2004; Thollander and Ottosson, 2008; Cagno and Trianni, 2013; Triannia *et al.* 2017).

3.2.3.3 South Africa Energy Intensity

Energy intensity is a critical part of ‘greening’. Energy intensity is a measure used to assess the energy efficiency of a particular economy calculated as units of energy per unit of gross domestic product (GDP). It is a useful metric that measures how efficiently a country uses electricity to

produce one unit of economic output, measured in kilowatt-hour (kWh). In short, energy intensity is a measure of the energy inefficiency of an economy (Faranda *et al.* 2007:2091). Using less energy to produce a product or provide a service result in reduced energy intensity (DoE, 2013).

It is also used as an economic metric to monitor whether a country is making progress in reducing emissions. The emissions of the country increase as the volumes of electricity consumed increase. At the same consumption level, the emissions should decrease with the introduction of energy efficiency. A lower energy intensity (energy is used more efficiently) means the country needs less energy per unit of gross domestic product (Statistics South Africa, 2019:182).

By international standards, the South African economy is extremely energy-intensive with a primary electricity use per unit of the GDP being amongst the highest in the world (Kohler, 2015:1). However, a historical trend analysis of the South African energy intensity shows that the energy intensity has been reducing over the past decades (WDI, 2018), with an improvement in energy efficiency between 2011 and 2015. In 2015, the energy intensity decreased from 2.07 TJ per million rands of GDP to 1.89 TJ per million rands of GDP, meaning the South African economy was more energy-efficient in 2015 relative to a 2011 baseline. The improvement in energy efficiency during this period was due to the different energy efficiency programmes mentioned in the National Energy Efficiency Strategy (Statistics South Africa, 2019:182).

The trend toward the improvement of energy efficiency is likely to continue with increasing innovation in technology and increasing pressure to reduce greenhouse emissions (Sebitosi, 2008). This trend has the potential to create opportunities for municipalities to improve their energy efficiency.

3.2.3.4 South African energy efficiency legal framework

The South African government is promoting energy efficiency policies through energy efficiency standards, financial incentives, and regulatory instruments (DEFF, 2020:24). The implementation of energy efficiency requires a multidisciplinary approach that includes command-and-control environmental regulations (legislation and energy policies), voluntary instruments (SANS 50001 standards and building standards) and market-based instruments (EEDSM incentives). The Department of Energy is responsible for preparing legislation and regulations for the governance

and implementation of energy efficiency, while the Department of Trade and Industry is responsible for preparing energy efficiency standards.

To better understand the implication of barriers to energy efficiency in South African municipalities, it is comprehended that the regulations that promote energy efficiency must be described (Brynard, 2005:660). For instance, the Electricity Regulation Act No.4 of 2006 (ERA) governs electricity generation, transition, and distribution. Section 2(a) of ERA sets out its objectives, which include, achieving the efficient, effective, sustainable, and orderly development and operation of electricity supply in South Africa. Section 2(e) of ERA seeks to promote the use of diverse energy sources and energy efficiency (South Africa, 2006a:6). Section 15(1)(u) of ERA allows the National Energy Regulator to place conditions on licences dealing with energy efficiency. Eskom plays a critical role as the dominant integrated utility at all levels of the electricity value chain (DMR, 2019:17).

The South African Constitution and government policies give municipalities the mandate to provide the services and infrastructure that are necessary to meet the basic needs of the poor and connect community-led development to national development objectives. The Constitution of the Republic of South Africa No.108 of 1996 (the Constitution) is the supreme law of the land, and no other law or conduct may conflict with it, nor the government do anything that violates it (South Africa, 2006b:3). Section 24 of the Constitution makes provision for ecologically sustainable development and the use of natural resources while promoting justifiable economic and social development.

Furthermore, section 78(1)(a) of the Municipal Systems Act No.32 of 2000 (MSA) requires that municipalities should consider the expected effect on the environment and human health when deciding on the mechanism of service delivery (South Africa, 2000). In terms of sections 73(1) and (2) of the MSA, which fleshes out the Constitutional mandates, municipalities are obliged to undertake their activities and deliver service in a manner that does not harm the environment. In terms of municipal functions, section 152(1)(b) of the Constitution set the objectives for municipalities by ensuring that municipalities provide services to communities in a sustainable manner (South Africa, 2006b:74).

The NEA allows the Minister to issue energy efficiency regulations. Section 19(g)-(n) of NEA deals with the minimum levels of energy efficiency in each sector of the economy and the procedures necessary for the application of energy efficiency technologies (South Africa, 2008). In terms of section 12L (5) of the Income Tax Act No.58 of 1962, a person and organisation may claim a tax allowance for energy efficiency savings (South Africa, 1962).

Municipalities must address electricity service delivery by addressing access to electricity services and stimulating the local economy (SALGA, 2013:7). Municipal investment in energy efficiency is recognised as a crucial method for achieving this objective (SALGA, 2017:1). In terms of section 152(2) of the Constitution, municipalities must strive within their financial and administrative capacity, to achieve these objectives.

However, municipalities in the country are struggling to fulfil this developmental mandate, with some failing altogether (SALGA, 2017). Against this backdrop of service delivery backlogs, local governments also critically need to engage with the challenge of planning and implementing energy efficiency initiatives, given that South Africa is predicted to suffer from the impacts of climate change and electricity shortages (e.g., Asha and Makalela, 2020; DoE, 2019a; Eberhard, 2011).

3.2.3.5 South Africa's energy efficiency policies and programmes

While barriers exist, it is also important to note that energy efficiency policies and practices may present a strategic priority to improve energy efficiency. If successfully implemented, energy efficiency policies and regulations should decrease energy intensity and improve energy efficiency (Palm and Thollander, 2010: 3255). It is widely understood that energy efficiency improvement is achieved by changing how electricity is managed (Bilous, 2020:19). Best practices in energy efficiency policies require the design of robust programmes, evaluation of policies, clear strategies, and plans, as well as institutional and operational capability (Filippo, 2012:41).

South Africa has enacted a wide array of policies and programmes to encourage energy efficiency, many of which were originally promulgated to respond to the 2007 electricity crisis (de la Rue du Can *et al.* 2013:3). The formal strategy of energy efficiency was firstly proposed in the

1998 White Paper on Energy Policy (Singh and Lalk, 2016:289). The South African White Paper provides a policy framework for energy decision-making by outlining sustainable energy objectives for energy policy (Covary and Aversch, 2013:594). The policy promotes energy efficiency awareness and encourages energy efficiency practices (Kohler, 2015:2). The 2011 White Paper on Climate Change Response identifies energy efficiency, demand management and reduction in emission intensity as the major opportunities.

In 2003, the DME published an Integrated Energy Plan as a framework for energy policy decision-making and the development of various energy sources and technologies (Winkler, 2006 11). In 2005, the DME released the first National Energy Efficiency Strategy (NEES) which aimed to respond to the increasing demand for energy and improve resource use and reduce the national environmental footprint (DoE, 2015:1).

In the National Energy Efficiency Strategy, the government set sectoral and economy-wide energy efficiency goals and targets across the economy to support energy efficiency utilisation (DEFF, 2020:24-30). NEES is a key guiding policy to support the implementation of energy efficiency measures in South Africa (DEFF, 2020:24). Its overall goal is to ensure that all South African spheres of government (national, provincial, and municipal) contribute to the national greenhouse gas mitigation, energy efficiency and energy security targets. Therefore, the energy efficiency measures by the municipalities will make a big impact on the national targets.

Furthermore, NEES intends to implement a variety of regulatory measures, and awareness-raising measures, reduce environmental pollution, reduce carbon dioxide emissions, enhance electricity security, and reduce additional power generation capacity (Covary and Aversch, 2013:594-595). The vision of the strategy is to strive for affordable electricity and minimise the effects of electricity usage on human health and the environment (SEA, 2013:3).

The 2005 NEES was revised after the 2007/2008 rolling electricity blackouts to accelerate the development of energy efficiency policies and to make their implementation effective (Covary and Aversch, 2013:591). The post-2015 National Energy Efficiency Action Plan (NEEAP) was gazetted in 2016 and aims to build on the achievements of the first NEES, which saw higher improvements in energy intensity by stimulating further energy efficiency through a combination of financial incentive schemes, demonstration programmes, awareness campaigns, voluntary

agreements, and robust legal and regulatory frameworks (DoE, 2018:4; Covary and Aversch, 2013:591).

NEEAP has a 2030 horizon with redefined targets that aim to contribute toward the reduction of South Africa's overall electricity consumption through implementing energy efficiency initiatives. According to this strategy, the following sectors are expected to reduce their electricity consumption: the mining sector (15%), the public and commercial sector (37%); residential sector (33%); transport (39%); agriculture (30%) and 29% for the entire economy by 2030 (DoE, 2016a:4; DoE, 2018:4). Table 3-1 captures the 2030 energy targets for public buildings and municipal services.

Table 3-1: Municipal Energy Efficiency Targets outlines in the post-2015 NEES
Source: DoE (1996)

Variables	National Energy Efficiency Strategy	
Public Building	<i>Goal</i>	Accelerate the current rate of improvement in the energy consumption per square metre in buildings occupied by the building sector at national, provincial & municipal level.
	<i>Target</i>	50% reduction in the specific energy consumption by 2030.
Municipal services	<i>Goal</i>	Accelerate the reduction in the specific energy consumption per resident in delivering municipal services.
	<i>Target</i>	20% reduction in energy intensity of municipal service provisions, this includes street lighting, traffic lights, water supply and wastewater treatment. 30% reduction in the fossil fuel intensity of municipality vehicle fleets.

In 2015, the United Nations General Assembly established 17 Sustainable Development Goals (SDGs) that are intended to be achieved by 2030. These SDGs are colloquially known as Agenda 2030. Sustainable Development Goal 7 aims to ensure access to affordable, reliable, sustainable, and modern energy for all. The goal has three outcome targets i.e., ensure universal access to affordable, reliable, and modern energy services (target 7.1); increase the share of renewable energy in the global energy mix (target 7.2) substantially; and double the global rate of improvement in energy efficiency (target 7.3) (World Bank: 2019:1). The SDGs find expression within the National Development Plan (NDP), where 74% of the SDGs applicable to South Africa are integrated into the NDP (UNSD, 2019:25).

In 2005, goals were set, and support programmes were established to drive the uptake of solar water heaters with the NDP guaranteeing five million solar water heaters by 2030 (DEFF, 2020: xi). In 2010, South Africa initiated a national campaign for solar water heater mass rollout through Eskom with a target of installing 1 million solar water heaters by 2014 with a saving of 650MW of electricity demand (UNEP, 2015:159).

By 2030, the NDP targets that South Africa will have a less carbon-intensive electricity supply. Through the plan, the South African government is expected to implement the 2010-2030 Integrated Resources Plan (IRP) which seeks to promote energy supply diversification through increased use of energy efficiency management and technologies (South Africa, 2012:48; DME, 2003:25).

The government is expected to implement the Integrated Energy Plan (IEP), which seeks to intensify energy efficiency and demand-side management (NPC, 2018:16). Both the IRP and IEP make projections of electricity demand through to 2050 and consider how to supply that demand (groundwork, 2017:1). IRP intends to increase the clean energy mix to 30% in 2025 (DoE, 2013:4) whilst the NDP envisages that by 2030 South Africa will have an energy sector that provides reliable and efficient energy service at a competitive rate and affordable tariffs (NPC, 2018:13).

To further the efforts of promoting energy efficiency measures and the use of green technologies in the industry sector, the South African Industrial Energy Efficiency (IEE) programme was developed. The programme assisted industrial companies to reduce 1220 GWh with a saving of R1.7 billion in electricity costs between 2010-2015 (NCPC, 2015) and saved 2140 GWh between 2016-2019 through different electricity management systems optimisation projects (DEFF, 2020:34).

Despite numerous advances in energy efficiency policy developments, the energy efficiency regulatory environment has stalled, considering that the NERSA-funded EEDSM programmes that were managed by Eskom have been placed on hold. The attention has now shifted away from energy efficiency and more focus has shifted to the supply side generation capacity investment (UNDP, 2018:1).

3.2.3.6 South Energy Efficiency Standards

Energy efficiency policies and regulations are not the only ways to improve energy efficiency. Recent studies have found that a cost-effective way for energy efficiency improvement is to combine investments in energy efficiency policies with continuous electricity management practices (USAID, 2020; Longarela-Ares *et al.* 2020; Filipova *et al.* 2019). To further the efforts of reducing electricity use and greenhouse gas emissions the South African government is implementing energy efficiency and electricity consumption standards (World Bank, 2010).

The mandate for energy efficiency in public buildings is described in the National Building Regulations and Building Standards Act No.103 of 1977 and developed by the South African Bureau of Standards through the Department of Trade and Industry. The World Bank (2010) has shown that these standards if implemented correctly are effective instruments to reduce electricity use.

SANS 204:2011 standard specifies the design requirement for energy efficiency in new buildings and includes natural environmental control and air conditioning systems. SANS 10400: XA standard set minimum energy efficiency requirements in buildings and applies to residential and non-residential buildings. The standard for existing buildings does not exist at this point. SANS 1544:2014 standard outlines the requirements for producing Energy Performance Certificates for public buildings.

SANS 941:2014 standard is the energy efficiency standard for electrical and electronic apparatus and covers the energy efficiency requirements, measurement methods, and the maximum allowable standby power for a set of appliances to form the basis for mandatory regulation, and energy efficiency labelling for electronic appliances used in residential buildings (SABS, 2014). The energy efficiency labels would be attached to appliances that meet the requirements of energy performance standards. Appliances include washing machines, air conditioners, ovens, electric geysers, refrigerators, dishwashers, electric lamps and audio and video equipment (DEFF, 2020:27).

A more sensible and systematic approach to improving the organisation's energy efficiency is to establish and implement a standardised, process-based energy management structure. SANS

50010:2011 standard is probably the most used standard for the improvement of energy efficiency, reducing cost and improving environmental performance. In addition, this standard is used by organisations to quantify electricity savings and identify electricity-saving opportunities. SANS 50001 is a continual improvement framework that includes a stepwise loop called the Plan, Do, Check and Act (PDCA) cycle or the Deming cycle. This framework is used by organisations that want to incorporate electricity management into their everyday practices.

3.2.4 The implementation of energy efficiency in South African municipalities

The South African municipalities are implementing energy efficiency through a market-based scheme. Market-Based Instrument such as the Municipal EEDSM programme is touted as an initiative to reduce the economic barriers that exist due to market failures. The EEDSM programme is a conditional grant from the national fiscus, allocated by the National Treasury, through the Division of Revenue Act No.1 of 2010 (South Africa, 2010).

As a response to the 2007/2008 electricity blackouts, the National Treasury began its first efficiency programme with local government with the inception of the DoRA-funded Municipal EEDSM in 2009 (SALGA, 2013:10; Kruger and Tait, 2015:8) focusing strictly on supporting municipalities in upgrading their infrastructure with energy-efficient technologies (South Africa, 2010:190; Kruger and Tait, 2015:13), and reducing electricity consumption and improving energy efficiency (South Africa, 2010:190).

The EEDSM is available to all municipalities but limited in terms of the number of municipalities that can receive funding and the amount of funding each municipality can receive in a given year. Municipalities are often required to implement projects within one financial year, and it is, therefore, advisable to prepare baselines and tender documents in the previous year of applying for the EEDSM (SALGA, 2018:4)

The Municipal EEDSM programme finds expression in the National Energy Efficiency Strategy (DoE, 2016b:17). Various energy efficiency interventions have been implemented at the municipal level as a result of the programme, including the upgrading of municipal lighting infrastructure (energy-efficient traffic lights, new light-emitting diode lights (LED) on high masts), municipal building infrastructure (heating, ventilation, and air conditioning (HVAC)), energy-efficient water

infrastructure, installation of solar water heaters and energy-efficient wastewater treatment (USAID, 2020:1; DoE, 2019a:2), and/or encourage energy efficiency improvements in residential, commercial, and industrial sectors (World Bank, 2010:5).

The potential for electricity conservation in traffic and street lighting is substantial. Street and traffic lighting account for 15% to 30% of the total municipal electricity consumption and generate 70% to 80% of electricity savings per measure. It is therefore worth focusing on reducing the electricity consumption and operating costs from street and traffic lighting. Benefits of energy-efficient lighting include phasing out of environmental harmful lighting and reduction in maintenance costs (SACN, 2014:20-24).

Municipal buildings typically consume more than 30% of total municipal electricity consumption (SACN, 2014:30). Municipal buildings consist of municipal offices, community halls, amenities, creches, schools, post offices, parks, campsites, ablutions blocks, swimming pools, libraries, colleges, fire stations, police stations, water pump stations, etc.

Energy-efficient municipal buildings can reduce carbon dioxide emissions, as they use less electricity and fossil fuel. In municipal buildings improvement in energy efficiency can be achieved through retrofitting HVAC and lighting. In fully air-conditioned municipal buildings, the HVAC ranges from 30% to 60% of the building's total electricity consumption, whilst building lighting consumes about 20% to 30% (SACN, 2014:34).

The installation of energy-efficient motors can save municipalities about 5% of electricity consumption compared to traditional motors (SACN, 2014:41). If the variable frequency drives (VSDs) and energy-efficient motors are installed together, 20% of the electricity savings can be achieved. Additional electricity conservation can be achieved by changing fan belts driven systems and replacing mechanical aerators (SACN, 2014:41-42).

Since 2009, significant funding of over R1 billion has been dedicated to the EEDSM programme and 54 out of 294 municipalities have participated (Kruger and Tait, 2015:8-10). In the 2015/16 financial year, a total grant of R178 million was granted to the participating municipalities, resulting in a total electricity saving of 18.45 GWh against the projected savings of 23.57 GWh (South Africa, 2010:190). It is envisaged through the EEDSM programme that municipalities might

reduce their electricity bills by optimising electricity use improving the delivery of services, reducing greenhouse gas emissions undertaking retrofit of existing infrastructure (South Africa, 2010:190) between now and 2030 (DoE, 2016b:18).

Given all these benefits, energy efficiency in South Africa's electricity portfolio remains underutilised (SACN, 2014:13) and the overall success of the national municipal EEDSM programme is not fully known as there is no coordinated monitoring and evaluation of the entire programme (Mahomed, 2016:16 citing Sebitosi, 2010). During the energy efficiency implementation, municipalities face several related challenges, including poor capacity, weak administrative systems, undue political interference in technical and administrative decision-making, uneven fiscal capacity (South Africa, 2012:45), and a lack of appropriate, politically insulated commercial structures for the management of the supply and distribution of electricity (Newbery and Eberhard, 2007:6).

3.3 PART B - Empirical Literature

This section builds on the second objective of the study, which is to characterise the barriers that hinder energy efficiency in selected municipalities. To achieve this objective, it is important to understand described barriers and categorise these barriers into a taxonomy.

3.3.1 Taxonomy of barriers

The barriers to energy efficiency have already received much attention in the literature and the measures to overcome them have been analysed for decades in many studies and categorised in many ways (Aboltins and Blumberga, 2019; Buettner *et al.* 2018; Sorrell *et al.* 2011; Thollander *et al.* 2010; Reddy, 1991, Schleich, 2009; Singh and Lalk 2016; UNIDO, 2006). A barrier to energy efficiency is described by Sorrell *et al.* (2011:4) as the “*mechanism that inhibits investment in technologies that are energy-efficient and cost-effective for the potential investor in those technologies.*”

Verbrugger *et al.* (2010:852) defined barriers as the “*man-made factors or attributes that operate in between the actual and potential development or use.*” According to Thollander *et al.* (2010: 49), barriers are a result of the reluctance to adopt cost-effective energy efficiency measures and

they need to be identified and addressed to design innovative policy approaches to help realise the potential. These barriers cause an energy efficiency gap, which is the difference between the optimal level of energy efficiency and the actual level of achieved energy efficiency (Jalo *et al.* 2021:1), which means energy efficiency is not effective.

Energy efficiency barriers are discussed based on the categorisation (or taxonomy) created by Sorrell *et al.* (2000). Cagno *et al.* (2013:292) explained that taxonomies of barriers in theoretical frameworks are critical to obtaining a comprehensive picture of a complex problem. Due to its complexity, the literature has acknowledged that energy efficiency is impossible to capture, and instead, taxonomies are necessary to achieve an estimation of changes in energy efficiency (Reddy and Painuly, 2004:1434, Thollander *et al.* 2010: 65). Sorrell *et al.* (2000) point out that energy efficiency barriers vary depending on sectoral and regional conditions. The variations explain the range of empirical methodologies used for studying energy efficiency barriers (Reddy and Painuly, 2004:1432).

Several taxonomies have been developed in the literature and they are important to obtain a comprehensive picture of a complex problem, which incorporates barriers into electricity models and facilitates effective responses to reduce the impact of these barriers (Cagno *et al.* 2013:299). The systematic literature review revealed that the taxonomies developed from the studies described below, most of them were based on the literature review. This study follows the same approach. For this study, barriers are responsible for the creation of the energy efficiency gap (Jalo *et al.* 2021:1).

The debate on the barriers to energy efficiency was popularised by York *et al.* (1978) and Blumstein *et al.* (1980) on which a series of literature followed their work. The early classification of barriers to energy efficiency was by Blumstein *et al.* (1980) who attempted to provide systematic research of the barriers to energy efficiency that classified barriers into social and institutional. Blumstein *et al.* (1980) further described market barriers as the liquidity constraints that hinder access to financing energy-efficiency investment. The effect of market failure and lack of capital access is widely discussed in the literature on neoclassical economics. Market failure is described as a situation in which the allocation of goods and services is not Pareto efficiency resulting in a net loss of economic value (Thollander *et al.* 2013).

Stern (1986) found that consumers have incomplete and incorrect information regarding electricity use. Generally, consumers tend to overestimate the amount of electricity used. The principal-agent problem or sometimes referred to as split incentives are often cited in the literature that discusses the energy efficiency gap, especially in connection with the residential sector. The principal-agent is a barrier where a tenant lease building for commercial or industrial use from the landlord where the tenant pays the electricity bills and where the landlord may not allow for energy efficiency improvements (Backlund *et al.* 2012:392).

Hirst and Brown (1990) were the first to qualitatively examine the systematisation of barriers to energy efficiency whereby social, institutional, behavioural, and market-related barriers were examined. The barriers were condensed into two groups, structural and behavioural. Structural barriers included distortions in fuel prices, limited access to capital, governance fiscal, regulatory policies, codes, and standards. Behavioural barriers included perceived risk of energy efficiency investment, attitudes towards energy efficiency, perceived risk of energy efficiency investment, misplaced incentives, and information gaps. Their work was based on the literature overview of energy efficiency in the USA.

DeCanio (1993) identified factors that stimulate firms' decisions to adopt energy efficiency investments. He classified the barriers in a general way that includes bounded rationality, principal-agent problems, and moral hazard. Bounded rationality is a barrier to the diffusion of energy-efficient technology and describes that rationality is limited when a consumer makes a decision.

Many empirical studies of barriers to energy efficiency have examined the factors that impede the implementation of energy efficiency measures. Much of the literature focuses on identifying and defining the various barriers and failures affecting energy efficiency investments (Golove and Eto (1996), Singh and Lalk (2016), Longarela-Ares *et al.* 2020 Thollander and Ottosson (2008).

One of the most cited research papers explaining the energy efficiency gap is by Jaffe and Stavins (1994). These authors conceptualised the concept of the '*energy efficiency gap*' by arguing that there is a difference between the level of the cost-effectiveness of energy efficiency and the level of energy efficiency realised. This means that energy-efficient technologies can cost more upfront, but they often generate net savings. The authors classified energy efficiency barriers based on rational decision-making which excludes organisational and behavioural aspects. Their analyses

demonstrate that necessary preconditions for the energy efficiency gap include understanding market failure and non-market failure explanation for the diffusion of energy-efficient technologies. Market failures refer to any market-related factor that inhibits the improvement of energy efficiency (Cagno *et al.* 2012:760).

Golove and Eto (1996) studied the market barriers to energy efficiency and identified six market barriers to energy efficiency investments to be lack of access to finance, mispricing imposed by regulations, lack of information, flaws in market structure, a decision influenced by decision and misplaced incentives. The authors found that challenges due to market barriers suggested that there is a substantial efficiency gap between a consumer's actual investment in energy efficiency and those that are in the consumer's best interest.

Reddy and Painuly (1996) addressed the barriers to energy efficiency demand-side management for electricity conservation measures. The authors have divided barriers into institutional, technical, financial, cost, information and managerial.

It was the work of Weber (1997), which placed the studies on the barriers to energy efficiency on the grandstand. Weber (1997) qualitatively examined the basics of barrier frameworks which led to a typology that included institutional, organisational (political and legal), behavioural, and market barriers to explain the energy efficiency gap. Weber's work was based on a comprehensive literature overview of energy efficiency.

It was after the work of Sorrell *et al.* (2000) that the most referenced barrier taxonomy was published. Based on a comprehensive literature review, Sorrell *et al.* (2000) examined the determinants of barriers to the use of energy efficiency technologies in the industrial sector to develop a theoretical barrier framework. The authors prepared a taxonomy by systematically classifying the barriers into three broad categories, neo-classical economics, behavioural, and organisational theory.

This taxonomy is the most widely used classification of barriers. Like Weber (1997), the work of Sorrell *et al.* (2000) was based on a literature review and included case studies on various industries in the United Kingdom, Ireland, and Germany. The study concluded that the barriers are the reasons for the energy efficiency gap that exists in electricity management systems.

Following the work of Sorrell *et al.* (2000), there has been a sharp increase in scholarly interest in the research of barriers to energy efficiency. A study of the taxonomy of barriers to energy efficiency has been published in many disciplines that include sustainable development, mechanical engineering, building constructions, economics, and social sciences.

De Groot *et al.* (2001) surveyed firms in the Netherlands and identified factors that influenced the investment behaviour and attitude of Dutch firms towards economic policy and barriers to energy efficiency. In their assessment, they identified and categorised barriers into general, financial, and uncertainty. Their work was based on 135 companies from different industries in the Netherlands.

An important contribution to the study of barriers to energy efficiency can be found in the Third Assessment Report by the Intergovernmental Panel for Climate Change (IPCC, 2001) which conducted an extensive literature review on the barriers to mitigation of greenhouse gas emissions. In this research, the Intergovernmental Panel for Climate Change identified barriers to energy-efficient technologies.

The taxonomy created by Sorrell *et al.* (2004) and Schleich (2009) divides barriers into six main categories: hidden cost, access to capital, risk split incentives, imperfect information, and bounded rationality. Taxonomies are not used only to list and describe barriers, but they can also be used to model the link between barriers and drivers to energy efficiency, e.g., Reddy (2007) developed a new systematic classification and explanation of barriers and drivers in energy efficiency.

Shi *et al.* (2008) applied an analytical hierarchy process to examine and prioritise barriers in the Chinese SMEs and categorised them into policy and market barriers, financial and economic barriers, technical and information barriers, and managerial and organisational barriers. The authors concluded for SMEs to improve their energy efficiency, it is necessary to mitigate and remove various technical, regulatory, and institutional barriers and particular interest should be paid to energy policy and economic elements.

Although taxonomies are widely used to categorise barriers in multiple and overlapping ways, their comparison in different studies is extremely difficult (Sorrell *et al.* 2004:12), for instance, Thollander *et al.* (2010), proposed an interdisciplinary taxonomy of classification based on

theoretical approaches and differentiated between technical, technological, and social barriers. Their work was based on social and technological change.

Cagno *et al.* (2013) suggested a broader taxonomy that includes seven categories: technological, informational, economic, behavioural, organisational; competencies, and awareness. The authors argued that previous barrier taxonomies neglected the overlap between various barriers. Vogel *et al.* (2015) divided the barriers into three analytical levels, project level (building projects); sector level (building industry), and contextual level (Institutional framework). By implementing the proposed categorisation framework, it became clear that barriers in the building sector and the specific structural level were not connected. Their work was based on interview studies carried out in the Swedish building industry.

Singh and Lalk (2016:289), used a taxonomy that categorises barriers into economic, institutional, behavioural, and organisational, whilst Luthra *et al.*'s (2015:762) taxonomy also included market, awareness, and information, technical, ecological, geographical, political, and government issues. Stede (2017) categorised barriers into financial, information, behavioural, institutional, and external. He used expert sampling to categorise barriers in Italy. Based on the barrier frameworks and other various literature, the author evaluated the taxonomies to select a suitable barrier framework to be employed.

Energy efficiency requires consumers to change their behaviour regarding both electricity use and technology investment, however, barriers influence these behaviours (OECD/IEA, 2010:34). According to Aboltins and Blumberga (2019:195), the energy efficiency barriers are related to three big categories, that are, knowledge and information, financing, and regulatory environment. Although these taxonomies may be useful in classifying the barriers, Weber (1997:835) indicates that the barriers themselves are not mutually exclusive and they will have economic, behavioural, and organisational aspects.

As discussed above, studies of barriers to energy efficiency vary greatly in the manner in which they use taxonomical classification. Some studies employed organisations theories, and some relied on behavioural economics whilst others relied on neoclassical economics. Some studies used a combination of theories to describe the barriers to energy efficiency. Some studies highlighted additional barriers which are not included in Annexure B. Some of these barriers did

not qualify as barriers relevant to municipalities, however, they highlighted important contextual factors which greatly assist to understand the challenges of implementing energy efficiency.

3.4 PART C - Conceptual Framework

The taxonomy for this study is presented in Figure 3-1. Before presenting the taxonomy of barriers to energy efficiency, it is important to consider the conceptual framework that describes how the research is produced. Miles and Huberman (1994:18) stated that the conceptual framework “*explain, either graphically or in narrative form the main things that need to be studied*”. As previously mentioned, a conceptual framework for this study stems from the work of Sorrell *et al.* (2000) which categorised barriers to energy efficiency in a taxonomy dividing barriers into economic, organisational, and behavioural with further revisions in 2004 (see Sorrell *et al.* 2004) and 2010 (see Sorrell *et al.* 2010). Sorrell *et al.* (2004) remain the most in-depth investigation of energy efficiency.

Although various taxonomies were developed after the work of Sorrell *et al.* (2000), they do not provide a list of barriers for municipalities and local government. Most of these taxonomies are based in European organisations and focus on manufacturing sectors. To complement this overarching work of Sorrell *et al.* (2000), modifications were made to focus on the interrelationships between technical barriers, economic barriers, and governance barriers in South African municipalities.

Taxonomy is a two-letter word derived from the Greek words *taxis* which means ‘arrangement’ and *nomos* which means ‘law’. Taxonomy can best be understood as the ‘law of arrangement’. Thomson *et al.* 2018:4 described taxonomy as “*a scheme of classification in which things are organised into groups or types.*” A broader definition was proposed by Enghoff and Seberg (2006) on which the authors indicated that a taxonomy consists of (a) recognition, naming, and description of taxa, (b) comparison of taxa, (c) determination of variation and similarities, (c) classification of taxa, (d) identification of categories.

Cagno *et al.* (2012:762) suggested that a taxonomy of energy efficiency should take all the previous contributions from other researchers to identify the barriers thus avoiding any possible overlap. The overlap between barriers causes incorrect classification of the barrier (Sorrell *et al.*

2011:12). The taxonomy should be reduced to the minimum terms to analyse the possible interaction among independent barriers.

The study has presented a taxonomy that grouped barriers into (a) technical – technological barriers; (b) economic – market failures; financial barriers and behavioural economics barriers and (c) governance – energy policy, standards, regulatory and institutional barriers. The presented taxonomy of the barriers to energy efficiency is seen in Figure 3-1, The taxonomy devised from the literature is summarised in Annexure B and the results are discussed in Chapter 4.

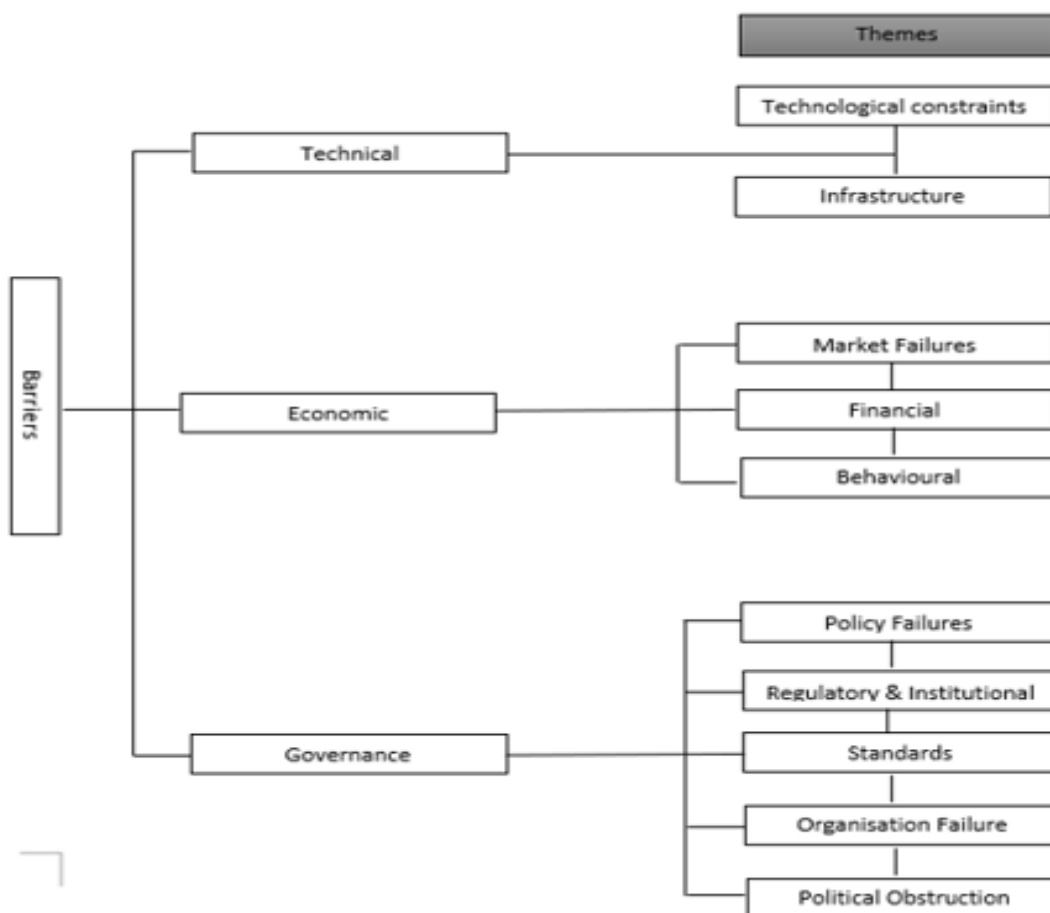


Figure 3-1: Conceptual framework for the classification of energy efficiency barriers
Adapted from Sorrell *et al.* (2004)

3.4.1 Technical Barriers

Technical factors that cause barriers to energy efficiency include inadequate technology and the lack of infrastructure necessary to support the technologies (Reddy, 2007:6; Shen *et al.* 2012:21).

From the literature, technology was identified as one of the major barriers to the willingness to invest in energy efficiency (Sorrell *et al.* 2004:30; Singh and Lalk, 2016:290; Reddy, 1991:18). Some barriers impede the implementation of energy-efficient technologies and practices in the energy sector and these barriers limit opportunities to capture electricity conservation. For more effective and sustainable electricity practices, municipalities need to have solid technical capacity (traits, skills, and knowledge) to drive the energy efficiency agenda.

The most used and common energy-efficient technologies include the use of LED lights, advanced electric motors, HVAC systems, high-efficiency boilers, solar water heaters, sensors, and controls. Barriers to energy efficiency technologies are both economic and regulatory. These technologies are very expensive and there is a lack of regulation to regulate their pricing.

3.4.2 Economic Barriers

Economic factors are identified as critical barriers to energy efficiency. In the economics literature, a link is made between energy efficiency and economic growth. Economic barriers are explained in the literature of conventional economic theory in terms of the energy efficiency gap or efficiency paradox (Sorrell *et al.* 2004; Thollander *et al.* 2010).

Economic barriers can exist due to economic market failures and economic non-market failures (Jaffe and Stavins, 1994:804). Most economists acknowledge the existence of market barriers to the penetration of various technologies that promote energy efficiency (Jaffe and Stavins, 1994, Sorrell *et al.* 2004). Energy efficiency measures are widely advocated as a means of both saving money and cost, effectively reducing the externalities associated with electricity use (Giraudet *et al.* 2018:2).

From the literature, it is evident that economic barriers play a critical component in the adoption and implementation of energy efficiency. It goes without saying that without finances, municipalities will not be able to build good energy efficiency programmes.

3.4.3 Governance Barriers

Governance barriers are barriers caused by the fragmentation in the legislative framework and funding mechanisms, institutional arrangements, and coordination mechanisms, which should

work together to support the implementation of energy efficiency strategies, policies, and programmes (Sorrell *et al.* 2011; Thollander *et al.* 2010: 46). The literature that discusses governance barriers to energy efficiency is based on institutional theory which provides that a lack of good governance within an economy is a key barrier to worsening electricity issues in any country. Several studies have drawn on institutionalism to interpret governance barriers in energy efficiency (Blumstein *et al.* (1980), Hirst and Brown (1990); Stede (2017).

The work of Palm and Thollander (2010:3256) applied neo-institutional theory to explain organisational behaviour relating to energy efficiency institutionalism to the challenge of regulating energy efficiency. Many studies applying institutional theory focused on the macro-dynamics of organisations (Weber (1997), Vogel *et al.* (2015), Singh and Lalk (2016).

3.5 Chapter summary

This chapter considered the theoretical aspects of energy efficiency barriers and as well as the in-depth literature review on energy efficiency, and how it was conceptualised to address energy challenges in South Africa. The Chapter was separated into three parts, Part A, B and C. Part A provided the narrative literature review on energy efficiency barriers, on which the definition of energy efficiency in the South African landscape is provided. Starting with the challenges of electricity in South Africa, the literature looked at how energy efficiency has been used to address the increasing energy demand by focusing on the Municipal EEDSM programme. The implementation of the EESM programme is, however, confronted with challenges such as lack of access to capital, limited institutional support as well as lack of skills and capacity constraints.

South Africa has a legislative framework for energy efficiency and other supporting legislation, programmes, and policies that support the implementation. Energy efficiency policies and legislation play a pivotal role in the implementation, management, and improvement of energy efficiency. Policies provide a strategic framework on which energy efficiency is implemented and measured. The legislation ensures compliance and enforcement of relevant regulations.

Generally, there is a good correlation between the existence of a regulatory framework and the improvement of energy efficiency. However, policies and legislation alone cannot fully reduce energy inefficiencies. Economic and technical factors are also taken into consideration when addressing barriers to energy efficiency. Effective electricity management is fundamental to the

operations of municipalities and has proven to further close the energy efficiency gap (Jalo *et al.*, 2021:1). Electricity is used by municipalities in the provision of municipal services, the operation and maintenance of municipal infrastructure such as office buildings, streetlights, waste treatment plants, public facilities etc.

Part B of the Chapter presented the empirical literature review. The review was undertaken to highlight the barriers to energy efficiency. Barriers to energy efficiency can take many forms and can include technical (Thollander *et al.* 2010), economic (Sorrell *et al.* 2000; Cagno *et al.* 2013), organisational (Hirst and Brown, 1990; Vogel *et al.* 2015),

Research on the barriers to energy efficiency in South African municipalities is important as it assists in identifying the main factors hindering the implementation of energy efficiency initiatives. This would enable policymakers to address these barriers and contribute positively to the environment.

Part C, the conceptual framework, drew from the theoretical and empirical literature reviews. Three essential key elements of energy efficiency barriers based on the overarching themes have been identified within the body of literature.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results to fulfil the primary aim of the study. This research set out to describe and classify barriers to energy efficiency in selected South African municipalities. In doing so, this chapter presents the recommendations from the experts. Several options are presented to improve energy efficiency in specific South African municipalities.

4.2 Profile of participants and participating municipalities

4.2.1 Participating municipalities

The participating municipalities were carefully selected using purposive sampling. The selection criteria were based on municipalities that have started the implementation process or are in the process to implement, they have already received a grant from the Department of Energy's Energy Efficiency Demand Side Management programme. Their energy efficiency projects should include one of the following performance areas, energy-efficient building lighting, heating, ventilation, and air conditioning (HVAC), energy-efficient streetlights, and new LED lights on high masts and energy-efficient water infrastructure (i.e., water pumps), and energy-efficient wastewater treatment.

Out of twenty-two participating municipalities, 16 (73%) were local municipalities, and 3 (14%) were District municipalities and Metropolitan municipalities respectively. A list of municipalities that participated in the study is presented in Table 4-1. The respondents' job titles and experience within energy efficiency projects were relevant to the study. Figures 4-1 and 4-2 provide evidence of the job titles and experience.

The study selected very highly skilled and senior-level management staff. The participants included 11(50%) Senior Managers, 3(14%) Executive Directors, 3(14%) Technical Directors, 4 (18%) Electrical Engineers and 1 (4%) junior official employed as an intern engineer. Seventeen (77%) of the respondents were trained as managers. The four experts, who are knowledgeable in energy efficiency were academics, consultants, and government officials.

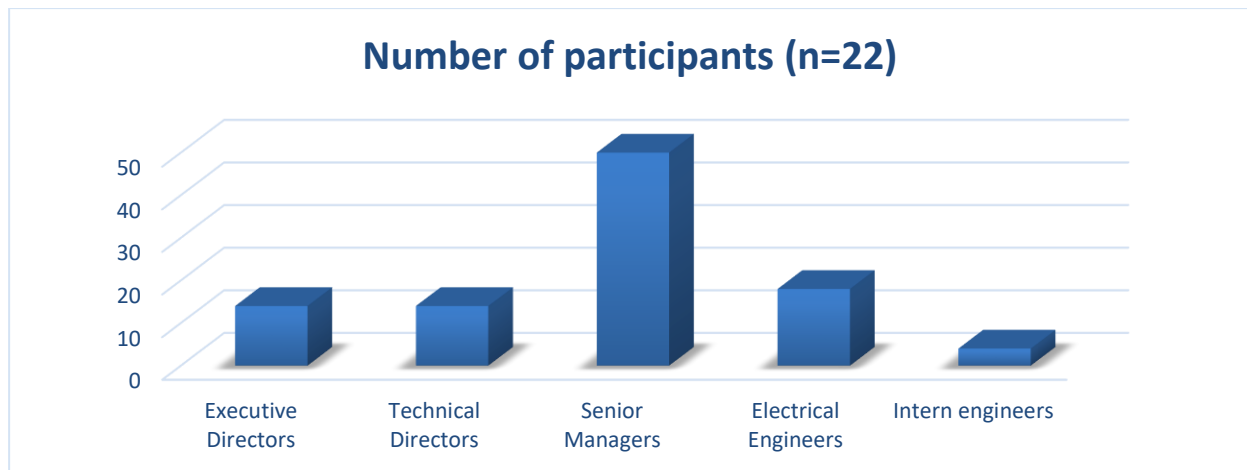


Figure 4-1: Description of municipal respondents based on skills level

Only 1 (4%) respondent had a PhD in Electrical Engineering, 5 (23%) had Bachelor's degrees in Electrical Engineering, and 16 (73%) had a national diploma in Electrical Engineering. Only 6 (27%) of the respondents received formal training in energy efficiency. All the respondents had experience in energy efficiency initiatives with an average of 6.3 years of experience amongst themselves. The most experienced respondent had over 17 years of total experience, whilst the least experienced only had 3 years of working experience. The individual respondent profiles are provided in Annexure A.

The experts had a total of 41 years of experience, with 1 having a PhD degree, 2 with Masters degrees and 1 with a Bachelor's degree all in Electrical Engineering. The respondent with a Bachelor's degree had 17 years of experience, thus qualifying as an expert. See Annexure A for a list of expert respondents.

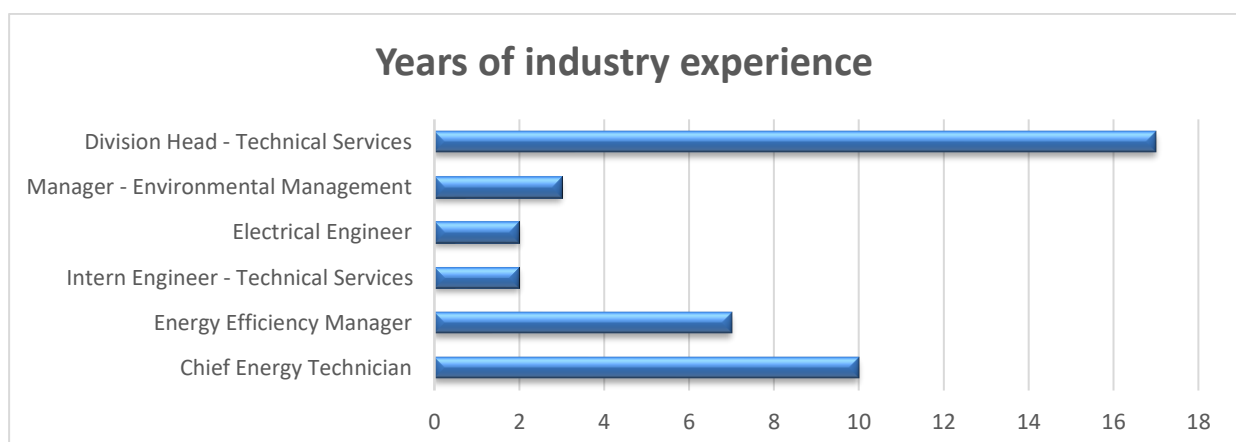


Figure 4-2: Municipal respondents' years of industry experience

Table 4-1: List of municipalities that participated in the study

Number List	Position	Type of Municipality	Region
1	Johannesburg Municipality	Metropolitan	Gauteng
2	Tshwane Municipality	Metropolitan	Gauteng
3	eThekweni Municipality	Metropolitan	KwaZulu-Natal
4	Mopani Municipality	District	Limpopo
5	Chris Hani Municipality	District	Eastern Cape
6	Overberg Municipality	District	Western Cape
7	Mogale City Municipality	Local	Gauteng
8	Breede Valley Municipality	Local	Western Cape
9	Drakenstein Municipality	Local	Western Cape
10	George Municipality	Local	Western Cape
11	Hessequa Municipality	Local	Western Cape
12	Mossel Bay Municipality	Local	Western Cape
13	Saldanha Bay Municipality	Local	Western Cape
14	Elundini Municipality	Local	Eastern Cape
15	Kouga Municipality	Local	Eastern Cape
16	Raymond Mhlaba Municipality	Local	Eastern Cape
17	Ngqushwa Municipality	Local	Eastern Cape
18	Kwadukuza Municipality	Local	KwaZulu-Natal
19	Umgenti Municipality	Local	KwaZulu-Natal
20	Madibeng Municipality	Local	North-West
21	Lekwa-Teemane Municipality	Local	North-West
22	Steve Tshwete Municipality	Local	Mpumalanga

The following discussion is based on the derived themes identified during the study. The purpose of the discussion is to interpret and describe the significance of the findings of the research objectives. Two categories were drawn from the data. The categories and themes are presented in Table 4-2.

Table 4-2: Categories and Themes

Categories	Themes
Municipal EEDSM Programme	Energy efficiency projects
Municipal capacity to implement energy efficiency projects	Energy managers
	Staff energy efficiency awareness
	Implementation mechanisms
	Co-operation between spheres of government
	Electricity management Programmes and Policies
	Energy audits

4.3 Results related to Objective 1: Status of energy efficiency initiatives in specific South African municipalities

4.3.1 Category 1: Municipal EEDSM Programme

In South Africa, no law or regulation directly controls energy management. Municipalities are therefore obligated to undertake the Energy Efficiency and Demand Side Management based on the regulatory policy on EEDSM for the South African Electricity Industry. With the current increase in electricity consumption and continuing electricity blackouts, the need for energy efficiency is clear.

Figure 4-3 represents the 2016/17 EEDSM fund allocations for the different municipalities that were included in this research. When evaluating the municipal grant allocations, it is evident that metropolitan municipalities receive more grants than the district and local municipalities. Respondents 12, 14 and 22 with the highest grant allocations were respondents from Metropolitan Municipalities. Sixteen (73%) of the respondents thought that metropolitan municipalities are capacitated and skilled to deal with energy efficiency practices.

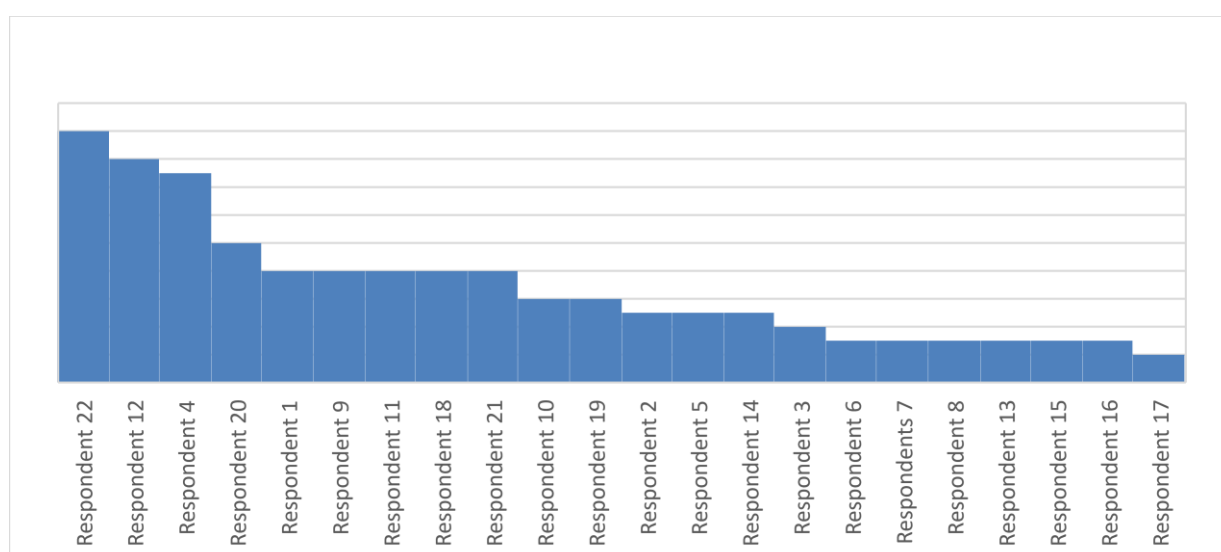


Figure 4-3: EEDSM Grant Allocation

Although the EEDSM is one of the well-performing electricity management initiatives within municipalities, there remain some key gaps expressed by the respondents including the inability to conduct technical audits as required by the EEDSM, lack of clearly articulated methodology for electricity management in municipalities, no clearly defined electricity-saving programmes, and lack of accurate baseline data for electricity consumption. Some respondents argued that section

12L tax incentive in terms of the Income Tax Act No.58 of 1962 which provides an allowance for private businesses to implement energy efficiency conservation measures, should be expanded to include municipalities.

When it comes to energy efficiency initiatives, the respondents were requested to list their energy-efficient projects, and the list included energy-efficient traffic lights, energy-efficient building lighting, heating, ventilation, and air conditioning (HVAC), energy-efficient streetlights, and new LED lights on high masts and energy-efficient water infrastructure (i.e., water pumps), and energy-efficient wastewater treatment. The respondents indicated that new energy efficiency capital projects were funded by municipalities, while projects with existing infrastructure were replaced with energy efficiency infrastructure.

Despite the government's initiative in providing funding for energy efficiency-related projects through the EEDSM scheme, only a third of the municipalities have realised the electricity-saving potential, while the majority of the municipalities have not realised the outcome of improving energy efficiency. Based on the result, fifteen (68%) of the respondents are unable to measure if they have reduced their electricity consumption and costs, due to their inability to conduct energy audits.

Theme 1: Energy efficiency projects

Figure 4-4 provides the breakdown of energy efficiency projects. From data provided by the twenty-two respondents, all the respondents have received the EEDSM grant, 22(100%) have fully installed LED street and traffic lights, 3(14%) have fully implemented water and wastewater treatment, 5(22%) have fully implemented solar water heaters.

Seventeen (77%) of the respondents have retrofitted their old municipal buildings with electricity-saving LED lights, while 13(59%) have installed HVAC technology for indoor and vehicular environmental control. 12(55%) have installed LED lighting and HVAC system in the new building, thus complying with SANS 10400: XA and SANS 204 Regulations which requires all new buildings to comply with the electricity performance parameters (DoE, 2013). All the respondents (100%) indicated that all their municipal office buildings have been retrofitted with electricity-saving LED lights. Three (14%) of the respondents have installed VSD on their water treatment pumps.

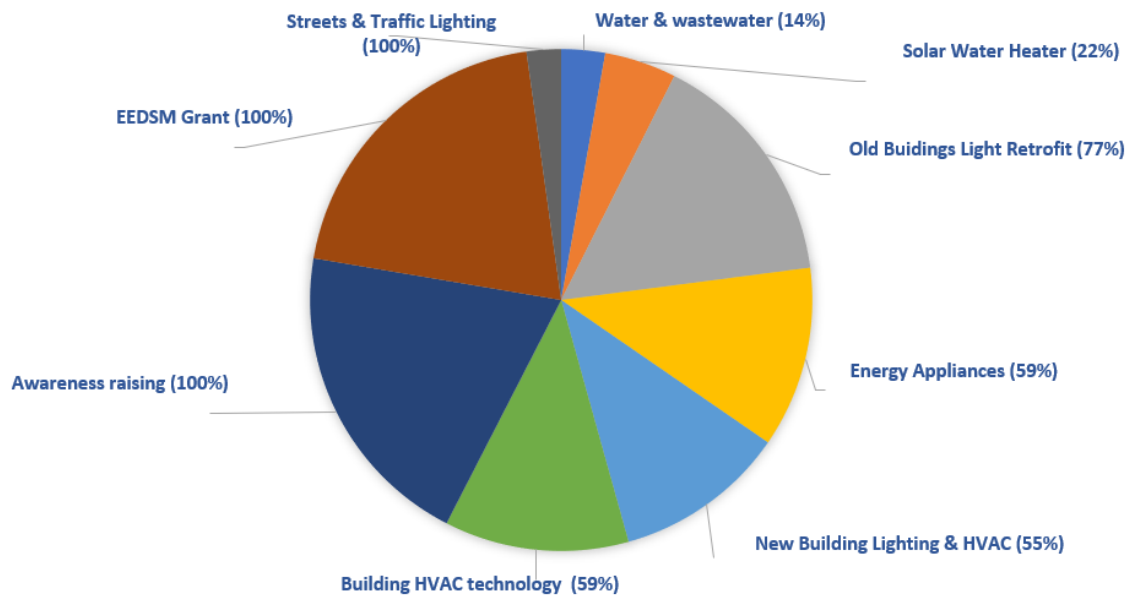


Figure 4-4: Breakdown of energy efficiency projects

Energy-efficient appliances can help to conserve electricity and save costs. Fifteen (58%) of the respondents indicated that their municipalities have converted most of their appliances, including refrigerators and heaters, to energy-efficient appliances. Five (23%) of the respondents indicated that their municipalities have installed solar panels to generate electricity and reduce the demand for coal-generated electricity on a few municipal buildings.

4.3.2 Category 2: Municipal capacity to implement energy efficiency projects

Theme 2.1: Energy managers

According to Singh and Lalk, (2006:283) electricity management systems are recognised as important instruments to improve energy efficiency in the industry. Despite the requirements of ISO 50001 standard for energy management systems and other best practices in energy efficiency, which recommend the appointment of an Energy Manager in organisations, only one respondent indicated that the municipality has an Energy Manager who manages the municipality's efforts to promote responsible use of natural resources and protection of the natural environment. Eighteen (82%) of the respondents indicated that although their municipalities do not have an Energy Manager, they at least have a Technical Services Manager, who coordinates all the technical activities of the municipalities. Technical Services Managers are not held accountable for electricity consumption as it was not their key performance indicator.

Theme 2.2: Staff energy efficiency awareness

A successful energy efficiency awareness campaign should include the consumers, residents of the municipalities as well as employees. When asked about the level of awareness of Sustainable Development Goals (SDG) Agenda 2030, only 20(90%) of the respondents showed some level of awareness. When asked about the level of awareness of the South African energy efficiency targets under the National Development Plant Vision 2030, the National Energy Efficiency Strategy and the Municipal EEDSM programme, only 17 (77%) of the respondents showed some level of awareness. Notably, senior management showed a great level of awareness, as they are mostly responsible for policy-making decisions.

Table 4-3: Awareness of SDG 7 Targets

Targets	Indicators	Responses
7.1 - ensure universal access to affordable, reliable, and modern energy services	7.1.1: Proportion of population with access to electricity.	Respondents pointed out that the country's electricity supply increased over the years. However, according to them, the number of households with access to electricity has declined. Seventeen (77%) of the respondents attributed this to the rapid immigration of foreign nationals into the municipalities, in which municipalities are expected to provide services. Nineteen (86%) of the respondents' attribute this to electricity non-payment, arguing that some households don't pay for electricity usage, thus causing municipalities to run at a loss.
	7.1.2: Proportion of population with primary reliance on clean fuels and technology.	With the high unemployment rate and increased poverty levels, 17 (77%) of the respondents pointed out that the majority of South Africans, who are poor, use unclean fuels that emit toxic gases for cooking, heating, and lighting.
7.2 - Increase the global percentage of renewable energy in the global energy mix.	7.2.1: Renewable energy share in the total final electricity consumption.	Respondents acknowledged the government's efforts to integrate renewable energy into the South African energy mix. However, there were concerns that this process is taking a long time. Common concerns in this regard were that renewable energy is costly and there seems to be no political will from the government to drive these initiatives. Five (23%) of the respondents indicated that their municipalities have installed solar panels to generate electricity and reduce the demand

Targets	Indicators	Responses
		for coal-generated electricity on a few municipal buildings.
7.3: Double the improvement in energy efficiency.	7.3.1: Energy intensity measured in terms of primary energy and GDP.	Respondents pointed out that energy efficiency improvement is directly linked to the country's economy. Eleven (50%) of the respondents indicated that the local energy policy lacks ambitions to achieve these targets, due to the country's failure to fast-track the implementation process. Lack of enforcement, lack of financial incentives, lack of skilled personnel at the local level, and a shrinking economy were cited as other barriers. Four (18%) of the respondents were not confident that South Africa will meet the SDG targets and cited that the goal's targets are too ambitious to be achieved.

Seventeen (77%) of the respondents were aware of the national strategies, plans and targets for energy efficiency. Respondents were also asked whether they have developed electricity improvement targets for their municipalities as part of the requirement of the National Energy Efficiency Strategy. Twelve (55%) of the respondents indicated that they have no energy efficiency targets in their municipalities due to the lack of technical capacity to draft energy efficiency policy and monitor energy efficiency targets, a lack of a municipal energy efficiency policy framework as a guide to draft the policy, a lack of finance to drive the policy objectives, and the lack of political will.

All the respondents agreed that South Africa's 2030 energy efficiency policy targets, as documented in the NDP and NEES, are too ambitious to be achieved at the set date. Some respondents also indicated that the country does not have enforcement strategies and mandatory reporting mechanisms. Currently, municipalities are not compelled to implement energy efficiency initiatives. Most respondents view this as blocking progress to achieve the 2030 targets.

When comparing the level of awareness within the three categories of municipalities, 3(100%) of the respondents from the Metropolitan Municipalities indicated awareness of the SDG and national energy targets, while their municipalities have also set energy efficiency targets. Three (100%) of the respondents from district municipalities were aware of the SDG targets, only 2

(67%) were aware of the national energy targets, while only 1 (33%) of the respondents indicated that the District Municipality has set energy targets.

Thirteen (81%) of the respondents from local municipalities indicated awareness of the SDG targets, 10 (62%) were aware of the national energy targets, while only 7 (44%) indicated that their local municipalities have set energy targets. Thollander *et al.* (2010) made similar findings when they found that people in urban municipal settings are more informed and knowledgeable on energy efficiency practices than those in rural municipal settings.

When asked how their municipalities raise public awareness of energy efficiency, most respondents stated that they use address energy efficiency issues through meetings, pamphlets distributed to the community, media and municipal newsletters, branded posters with energy efficiency tips and banners, roadshows, and campaigns. While there exists some level of energy efficiency awareness, the quality of energy efficiency implementation is poor (Kruger and Tait, 2015:14).

Theme 2.3: Implementation mechanisms

When the respondents were asked to evaluate their municipalities' capacity to implement energy efficiency projects, 17 (77%) indicated that all the work that involves energy efficiency is dealt with through the ESCo model and the municipal procurement system.

Theme 2.4: Co-operation between spheres of government

This study identified better cooperation between spheres of government as important. Sixteen (73%) of the respondents indicated that their municipalities have a good working relationship with the provincial and national governments, particularly in the sourcing of energy efficiency technologies.

Theme 2.5: Electricity management Programmes and Policies

Energy efficiency programmes and policies can assist municipalities in driving the implementation of energy projects that will optimise their electricity usage on an ongoing basis. When asked if their municipalities have energy efficiency policies, 20 (90%) of the respondents indicated that

their municipalities don't have energy efficiency policies. Only one respondent indicated that the municipality has an energy efficiency policy, while another indicated the municipality has a draft energy efficiency policy. This means that most municipalities don't have a formalised structure for implementing energy efficiency projects that will minimise or reduce electricity consumption.

Theme 2.6: Energy audits

According to Singh and Lalk, (2006:283) energy audits are recognised as important instruments to improve energy efficiency in the industry. When asked if their municipalities conduct energy audits to better understand their electricity consumption, 19 (86%) of the respondents indicated that their municipalities do not conduct energy audits as they lack the proper skills to conduct basic energy audits. Fifteen (68%) of the respondents did not know how to conduct energy audits and can't verify whether their electricity consumption is reducing. Seven (32%) of the respondents indicated that their municipalities conduct energy audits and can monitor the effectiveness of their energy efficiency initiatives and have achieved some electricity savings. Five (22%) of the respondents who conducted energy audits indicated that they had savings of 10-15% between 2018 and 2020.

Theme 2.7: Drivers for Energy Efficiency

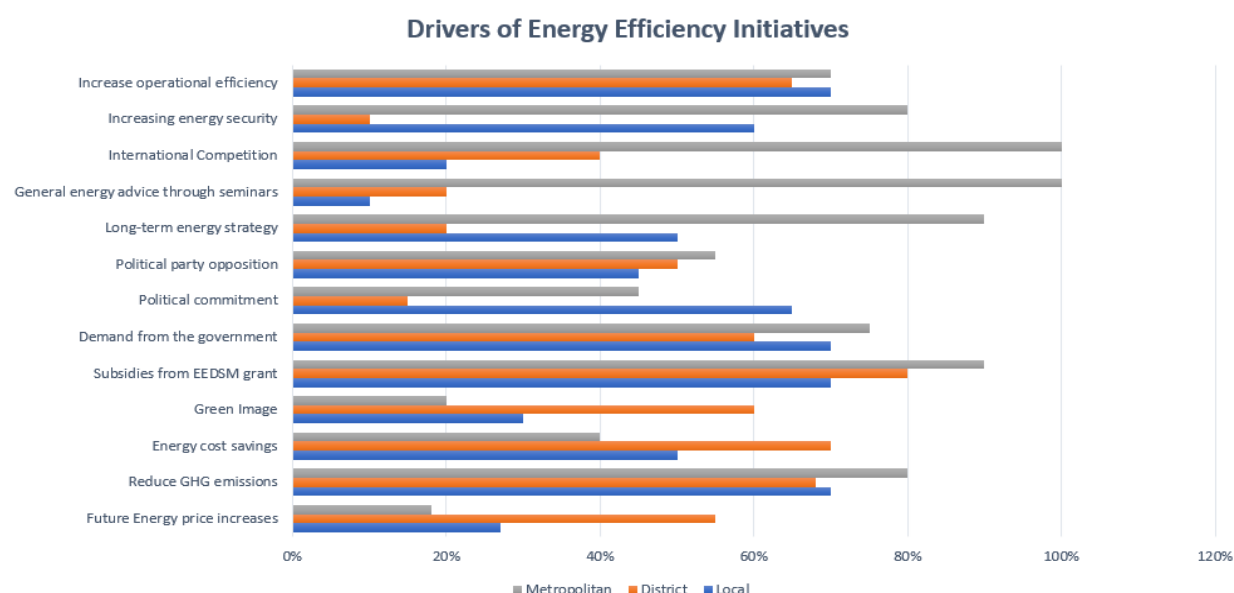


Figure 4-5: Drivers of energy efficiency initiatives

In the study of barriers to energy efficiency, it is important to understand the drivers for energy efficiency. Singh and Lalk, (2006:294) suggested that knowledge of the drivers of energy

efficiency is a prerequisite to describing the barriers thereof, as they influence the introduction and development of policy measures related to energy efficiency. Figure 4-5: provides the drivers of energy efficiency initiatives as described by the respondents.

4.4 Results related to Objective 2: Barriers to the implementation of energy efficiency initiatives

Table 4-4: Results from thematic analysis

Code	Themes	Categories
Technical	Technological	Lack of local energy efficiency technologies
		Poor installation of energy efficiency technologies
		Lack of maintenance of the newly installed energy efficiency technologies
		Lack of technical capacity within the municipality to identify, appraise, develop, and implement energy efficiency projects.
		Contractors (ESCOs) lack experience in project management
	Infrastructure	Municipal infrastructure is too old for energy efficiency retrofit.
		Lack of infrastructure to accommodate energy efficiency technologies.
Economic	Market Failures	Lack of local suppliers (ESCOs).
		Suppliers (ESCOs) are not paid on time.
		Suppliers (ESCOs) do not offer a diversity of energy efficiency technologies.
		Lack of good quality equipment, e.g., the light colour spectrum of LED fade over time.
		The demand for energy efficiency is too low.
	Financial	Energy efficiency technologies are often very expensive.
		Lack of internal funding for energy efficiency projects.
		Lack of finance to continue with energy efficiency projects.
	Behavioural Economic	Lack of willingness to invest in energy efficiency.
		Lack of information, awareness, and understanding from the municipal staff on the benefits of energy efficiency.
Governance	Policy Failures	Impractical government targets - a gap between the policy targets set by governments and the actual results executed by the municipalities
		Lack of energy efficiency policies at a municipal level.
		Lack of a well-defined energy efficiency implementation framework.
		Lack of clear energy conservation targets.
	Regulatory	Lack of regulatory framework and legislation for energy efficiency at a municipal level.
		Municipality's inadequate capacity to enforce mandatory measures and regulations.
		Lack of regulatory guides to enforce and monitor strategic outputs
	Standards	Lack of energy efficiency standards and labels
		Lack of effective measurement & verification (M&V) protocol and implementation for documenting energy savings in municipalities
		Lack of leadership from top executives to enhance energy efficiency.
		Lack of metered or recorded energy consumptions & conservation.
	Institutional	Energy manager lacks authority and influence
		Lack of political support to improve energy efficiency
		Political interference in energy management programs
		High levels of corruption impede the financial support to energy efficiency projects.
		Lack of coordination and cooperation between the stakeholders, i.e., the municipal, provincial, and national spheres

4.4.1 Technical barriers

The respondents were requested to rate the significance of seven technical barriers identified in the literature survey. Table 4-5 presents the rating scale of technical. As previously mentioned, a 5-point Likert scale was condensed into a 3-point Likert scale to allow for easy analysis of results. From the results, the important barriers included a *Lack of technical capacity within the municipality to identify, appraise, develop, and implement energy efficiency projects* and *Municipal infrastructure is too old for energy efficiency retrofit*.

Table 4-5: 3-Point Likert scale on technical barriers.

TECHNICAL BARRIERS		Responses		
	1+2	3	4+5	Total
	Unimportant	Moderate	Important	
Lack of local energy efficiency technologies.	59%	14%	27%	100%
Poor installation of energy efficiency technologies.	55%	27%	18%	100%
Lack of maintenance of the newly installed energy efficiency technologies.	50%	18%	32%	100%
Lack of technical capacity within the municipality to identify, appraise, develop, and implement energy efficiency projects.	28%	14%	58%	100%
Contractors (ESCO) lack experience in project management	41%	36%	23%	100%
Municipal infrastructure is too old for energy efficiency retrofit.	36%	23%	41%	100%
Lack of infrastructure to accommodate energy efficiency technologies.	50%	27%	23%	100%

4.4.1.1 Important technical barriers

- **Lack of technical capacity within the municipality to identify, appraise, develop, and implement energy efficiency projects.**

This barrier was rated important with a combined rating score of 58%. The research conducted by the United Nations Industrial Development Organisation (2006) on energy efficiency confirms the results of this study. The study indicated the lack of qualified individuals and organisations to identify energy efficiency initiatives. These individuals cannot carry out energy audits and analyse performance. Lack of technical skills leads to difficulties selecting and installing new energy-efficient equipment (Reddy, 1991).

- **Municipal infrastructure is too old for energy efficiency retrofit.**

This barrier was rated important with a combined rating score of 41%. In the report on the status of municipal infrastructure SALGA (2013) found that old municipal infrastructure is an ongoing challenge in the implementation of energy efficiency. SALGA (2017) indicate that municipalities have inherited old and ageing infrastructure, some of it 30 years old which are overdue for replacement.

Older infrastructure is often not being renewed when it needs to be and there are no adequate plans for preventative maintenance of new infrastructure. Municipalities are confronted with the challenges of maintaining ageing infrastructure with limited funding. The old and ageing municipal infrastructure used in water and wastewater treatment and HVAC technology in buildings is often less reliable as is it prone to breakdowns, consumes more electricity, and produces higher emissions.

4.4.1.2 Unimportant technical barriers

- **Lack of local energy efficiency technologies**

This barrier was rated unimportant with a combined rating score of 59%. The US EPA (2016) found a connection between the availability of local energy efficiency technologies and improvement in energy efficiency. The report explained that local governments and municipalities can take a range of approaches to promote energy efficiency technologies in their operations and their communities.

- **Poor installation of energy efficiency technologies**

This barrier was rated unimportant with a combined rating score of 55%. These results are in contrast with the finding made by OECD/EIA (2010), who studied ESCos across European countries. The empirical study identified *poor installation of energy efficiency technology* as one of the major technical barriers. The OECD/EIA study found that some ESCos use unpractised energy efficiency technologies and lack an understanding of energy efficiency technologies. In the South African market, there are few energy efficiency service providers with the necessary experience to implement energy efficiency projects.

- **Lack of maintenance of the newly installed energy efficiency technologies**

This barrier was rated unimportant with a combined rating score of 50%. The report on the South Africa Cities Network (2014) provided that municipalities that newly installed energy efficiency technologies for street and traffic lights reduce maintenance costs. According to the report LED light fitting lasts 5 to 8 years. Municipalities that install energy-efficient technologies for pumps and pumping gain up to 30% through maintenance improvement. Contrary, old technologies require higher maintenance.

- **Contractors (ESCO) lack experience in project management**

This barrier was rated unimportant with a combined rating score of 41%. However, OECD/EIA (2010) found that some ESCOs use unpractised energy efficiency technologies and lack an understanding of energy efficiency technologies.

- **Lack of infrastructure to accommodate energy efficiency technologies**

This barrier was rated unimportant with a combined rating score of 50%. Reddy (2007) and Shen *et al.* (2012) indicate the lack of infrastructure as a barrier to accommodating energy efficiency technology. Lack of human capital infrastructure includes the lack of skilled and properly trained people. Due to this barrier, the risk of malfunctioning and underperformance is high, and the adoption of electricity technologies is also high. Reddy (1991:951) indicates the lack of technical electricity infrastructure may constitute a barrier to energy efficiency. The author further emphasizes the lack of technical infrastructure may be the result of regulatory failure.

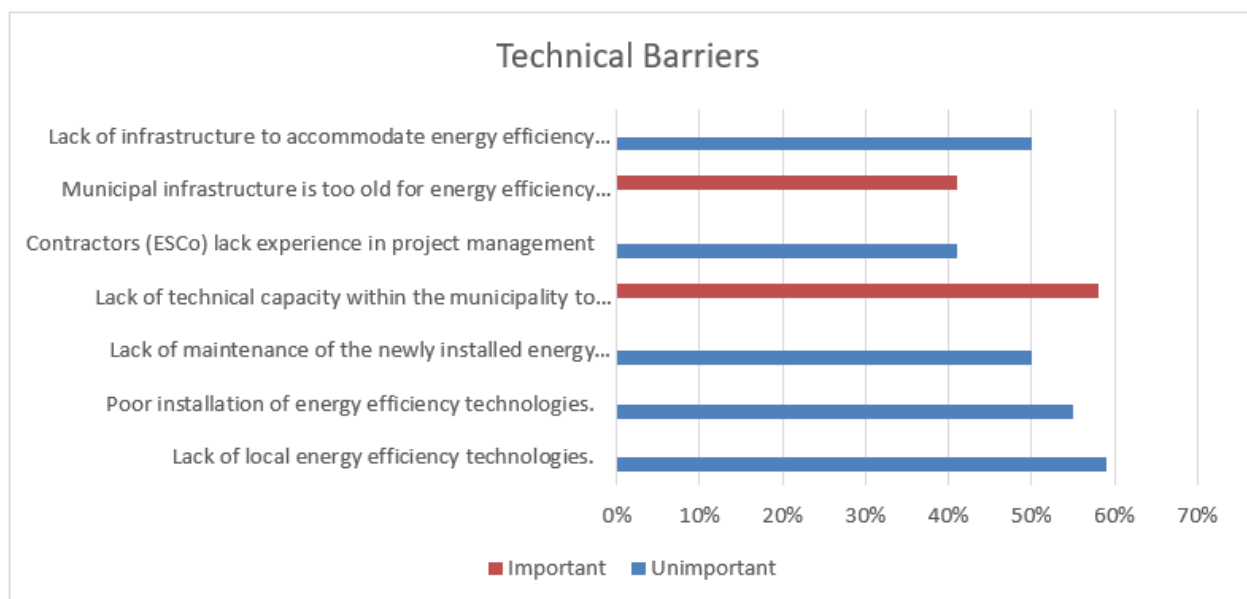


Figure 4-6: Graph of technical barriers

According to the experts, poor and old municipal infrastructure, poor maintenance, and unskilled staff were some of the challenges facing the municipalities. These challenges are in most cases attributed to political interference, lack of accountability, lack of transparency, lack of accountability, corruption, nepotism, poor human resource policy, employee incapacity, and poor planning. Expert respondents agree that municipalities in general, lack the technical capacity to effectively reticulate electricity function, which is a constitutional mandate. They mentioned the politicisation and de-professionalisation of the State had the worst impact on municipalities and have caused skill shortages in that political appointees are deployed to manage senior positions related to service delivery with little or no experience, and no background in the state of local infrastructure.

4.4.2 Economic barriers

The respondents were requested to rate the significance of nine economic barriers identified in the literature survey. Table 4-6 presents the rating scale of economic barriers.

Table 4-6: 3-Point Likert scale on economic barriers

ECONOMIC BARRIERS	<i>Responses</i>			
	1+2	3	4+5	Total
	Unimportant	Moderate	Important	
Lack of information on the technical and technological parameters of energy efficiency products	64%	18%	18%	100%
Lack of local suppliers (ESCOs).	55%	18%	27%	100%
Suppliers (ESCOs) do not offer a diversity of energy efficiency technologies.	64%	27%	9%	100%
Lack of good quality equipment, e.g., the light colour spectrum of LED fade over time.	64%	9%	27%	100%
The demand for energy efficiency is too low.	41%	36%	23%	100%
Energy efficiency technologies are often very expensive.	14%	27%	59%	100%
Lack of internal funding for energy efficiency projects.	10%	0%	90%	100%
Lack of willingness to invest in energy efficiency.	19%	23%	59%	100%
Lack of awareness of the benefits of energy efficiency from the municipal staff	27%	27%	46%	100%

4.4.2.1 Important economic barriers

- **Energy efficiency technologies are often very expensive**

This barrier was rated important with a combined rating score of 59%. According to OECD/EIA (2010:35), energy efficiency technologies are generally more expensive than traditional electricity-intensive technologies. However, in most cases, costs will decline as production volumes increase. Emphasis should also be placed on lowering manufacturing costs (Singh and Lalk, 2016). A study of the Chinese motor market highlighted the high relative cost of imported technology and the lack of access to capital (Zhang *et al.* 2017).

- **Lack of internal funding for energy efficiency projects**

This barrier was rated important with a combined rating score of 90%. A commonly cited barrier within the energy efficiency literature is the lack of access to capital (Hirst and Brown, 1990). The simplest and most direct way of funding electricity projects is by using internal capital or existing budgets.

The respondent indicated that their municipalities lack the internal finances to pursue energy efficiency projects. This is primarily due to a lack of finance within municipalities. According to Aboltins and Blumberga (201and 9) and Asha and Makalela (2020), energy efficiency projects must compete with other priorities within an organisation. This means that a project with excellent financial returns and positive environmental results may be rejected in favour of other organisational needs. Shen *et al.* (2012) explained that external financing is one way to overcome these barriers. In some municipalities, energy efficiency has a low priority compared to other initiatives that seek to reduce greenhouse gas emissions.

- **Lack of willingness to invest in energy efficiency**

This barrier was rated important with a combined rating score of 59%. The question of why organisations do not invest in energy efficiency is widely discussed in the neoclassical theory of investment that highlights market failure as the main obstacle (Evans *et al.* 2021, Cagno and Trianni, 2013). Lack of willingness and commitment from top management is a contributory factor to this challenge (Lihalo, 2013:10). Numerous studies found that energy efficiency is typically a low priority within firms, due to the lack of senior management engagement on the issue (Ozturk *et al.* 2019; Evans *et al.* 2021).

An experiment by Shafron *et al.* (2000) evaluating the willingness to invest in energy efficiency showed that organisations are not willing to invest unless there is an incentive that will encourage them to invest. Behavioural barriers hindering organisations from investing include a lack of commitment or resources from senior levels, a lack of interest and a reluctance to disrupt current operations (Evans *et al.* 2021:1). Other variables affecting willingness to invest include educational level and the type of manager.

The experts indicated that the financial barrier is compounded by municipalities that place a low priority on investing in energy efficiency projects. Similarly, Hasanbeigi *et al.* (2010) in their study of the largest cement companies in Thailand concluded that top management is more concerned with production and has shown limited attention to energy efficiency. Management that does not know the benefits of energy efficiency tends not to invest. SALGA (2017:1) explained that for municipalities, investment in energy efficiency is recognised as a crucial method for achieving the objectives of the NDP.

- **Lack of awareness of the benefits of energy efficiency from the municipal staff**

This barrier was rated important with a combined rating score of 46%. Literature on the awareness of the benefits of energy efficiency is vast and varied. According to Mineto *et al.* (2018:424), the awareness barrier relates to a lack of knowledge regarding the positive impact adoption of energy-efficient technologies can have on the business case. UNIDO (2006:25) provided that the level of awareness and knowledge of different energy efficiency technology sources may differ from region to region. Broad public awareness of energy efficiency requires large campaign rollouts to educate the public on improved energy efficiency (DoE, 2018:14).

4.4.2.2 Unimportant economic barriers

- **Lack of information on the technical and technological parameters of energy efficiency products.**

This barrier was rated unimportant with a combined rating score of 64%. Contrary to the findings of (Schleich, 2009), who conducted a comprehensive survey of industrial, public, and commercial organizations in Germany, found that a lack of information about electricity consumption is an important barrier in seven out of the nineteen sectors examined. Sorrell *et al.* (2011) explained the lack of information is generally found to be important for organizations who want to improve their energy efficiency. UNIDO (2015) provided that easy access to relevant information and

awareness of proven energy efficiency measures and programmes are typically missing. Schleich (2007:88) provided that the lack of information on energy efficiency opportunities may lead to cost-effective opportunities being missed.

Reddy (2013) and Reddy and Painuly (2004) who studied energy efficiency implementation in industrialised countries found that the lack of energy efficiency investment is partly due to limited information on electricity consumption, lack of awareness of energy efficiency technologies, and the cost of various investment options. Sorrell *et al.* (2004:4) found that lack of information results in the technology's users making ill-informed decisions and further leads to missed cost-effective opportunities. Schleich (2007) pointed out that the lack of expertise, time and capital often prevents companies from implementing electricity-saving measures or from gaining access to the energy services market.

- **Lack of local suppliers (ESCOs)**

This barrier was rated unimportant with a combined rating score of 55%. This finding is contrary to the findings in the literature, e.g., Aboltins and Blumberga, (2019) provided that the lack of localised ESCOs leads to the shortage of energy efficiency technologies when needed. The authors argued that a localised supply chain could reduce costs. The problems in the supply chain of energy efficiency technology are highlighted by Ürge-Vorsatz *et al.* (2007) who argued that a more localised approach to procuring energy efficiency technologies could be the answer to greater flexibility and control in the supply chain.

- **Suppliers (ESCOs) do not offer a diversity of energy efficiency technologies.**

This barrier was rated unimportant with a combined rating score of 64%. Shen *et al.* (2012:21) provided that a lack of diversified technology offerings from ESCOs has raised concerns about the energy efficiency investment. Despite the existence of diversified energy efficiency technologies, their sources are small and limited, making them very hard to fill the gap for electricity conservation.

- **Lack of good quality equipment, e.g., the light colour spectrum of LED fade over time.**

This barrier was rated unimportant with a combined rating score of 64%. Despite the diversity and efficiency of electricity technologies, access to poor quality energy-efficient technologies results

in electricity wastage, destruction of property, reduced energy efficiency and loss of life (Covary and Aversch, 2013).

- **The demand for energy efficiency is too low.**

This barrier was rated unimportant with a combined rating score of 41%. The global energy efficiency demand is growing faster with SDG energy efficiency targets encouraging countries around the world to double the global rate of improvement in energy efficiency by 2030. The latest data show that the world is making progress toward achieving the targets of SDG7 (World Bank, 2019).

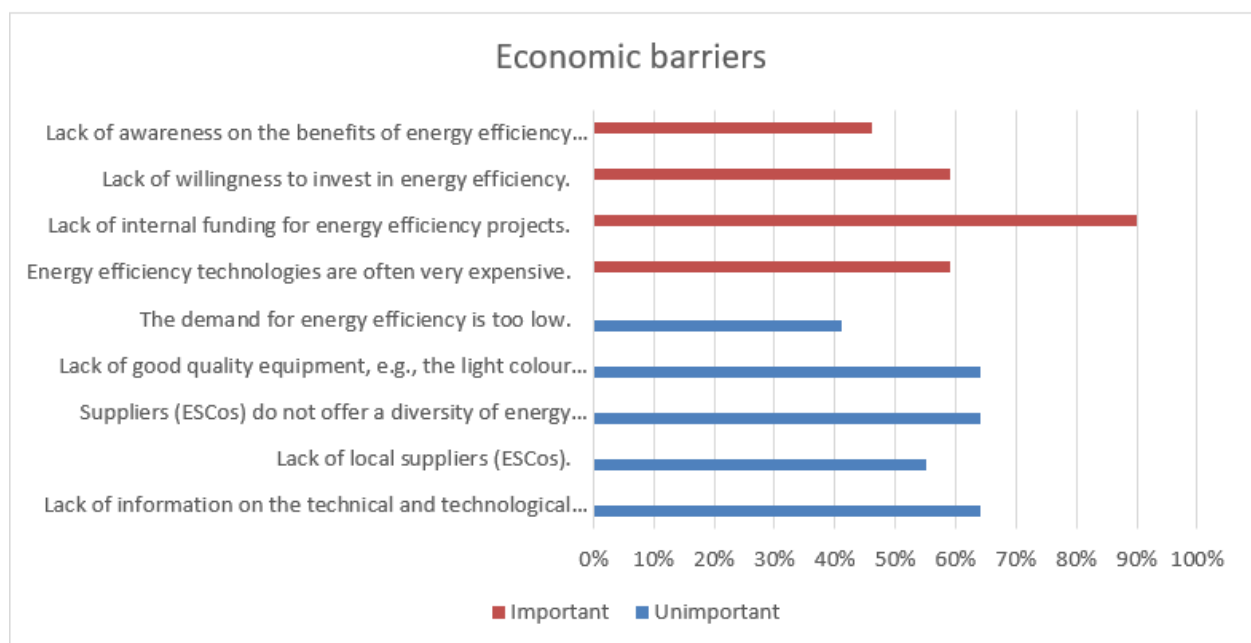


Figure 4-7: Graph of economic barriers

4.4.3 Governance barriers

The respondents were requested to rate the significance of seventeen governance barriers identified in the literature survey. Table 4-7 presents the rating scale of governance barriers.

Table 4-7: 3-Point Likert scale on governance barriers

GOVERNANCE BARRIERS	Responses			
	1+2	3	4+5	Total
	Unimportant	Moderate	Important	
Impractical government targets - a gap between the policy targets set by governments and the actual results executed by the municipalities	18%	36%	45%	99%
Lack of energy efficiency policies at the municipal level	23%	14%	64%	101%
Lack of a well-defined energy efficiency implementation framework.	18%	23%	59%	100%
Lack of clear electricity conservation targets.	18%	23%	59%	100%
Lack of regulatory framework and legislation for energy efficiency at the municipal level.	27%	23%	50%	100%
Municipality's inadequate capacity to enforce mandatory measures and regulations.	41%	27%	32%	100%
Lack of regulatory guides to enforce and monitor strategic outputs	45%	18%	36%	99%
Lack of energy efficiency standards and labels	23%	50%	23%	100%
Lack of effective measurement and verification (M&V) protocol and implementation for documenting electricity savings in municipalities	36%	36%	27%	99%
Lack of leadership from top executives to enhance energy efficiency.	27%	32%	41%	100%
Lack of metered or recorded electricity consumption & conservation.	50%	23%	27%	100%
Energy manager lacks authority and influence	36%	18%	45%	99%
Lack of political support to improve energy efficiency	36%	18%	45%	99%
Political interference in electricity management programs	36%	36%	27%	99%
High levels of corruption impede the financial support to energy efficiency projects	64%	14%	23%	101%
Lack of coordination and cooperation between the stakeholders, i.e., the municipal, provincial, and national spheres	68%	14%	18%	100%

4.4.3.1 Important governance barriers

- **Impractical government targets - a gap between the policy targets set by governments and the actual results executed by the municipalities.**

This barrier was rated important with a rating score of 45%. Brynard (2005) made a similar finding, where organisations set targets that are impractical and almost impossible to achieve. South Africa set challenging targets for energy efficiency improvement within the NDP 2030 Vision which correlates with the UN SDG 2030 Targets. Within the NEES, municipalities are required to reduce their electricity consumption by 50% by 2030 and 20% reduction in energy intensity.

The shortcoming of the NEES is the setting of ambitious targets which exceed the real capacity of municipalities to achieve these goals and the overestimation of the true impact of this strategy.

- **Lack of energy efficiency policies at the municipal level**

This barrier was rated important with a combined rating score of 64%. The lack of an effective energy efficiency policy is a major barrier for municipalities that want to implement energy efficiency initiatives. Covary and Aweresch (2013) found that a lack of energy efficiency policy is caused by incompetent officials, corruption, lack of resources and/or bad governance. Hasanbeigi *et al.* (2010) in their study of the largest cement companies in Thailand concluded that a lack of effective policies is caused by a lack of awareness of existing laws and regulations on energy efficiency.

Municipal respondents indicated that there is a lack of internal policies and procedures that could promote the adoption of energy efficiency in municipalities. While this is an organisational-related barrier, it does not remove the need for institutional support in specifying such policy and mandating compliance. The energy policy fragmentation and lack of implementation of the NEES, lack of energy efficiency performance management and lack of finance to invest in energy efficiency monitoring technologies were cited by the experts as factors that have created a gap in understanding whether energy efficiency has had an impact in reducing electricity demand in municipalities.

- **Lack of a well-defined energy efficiency implementation framework.**

This barrier was rated important with a combined rating score of 59%. Shen *et al.* (2012) in their study of the largest cement companies in China concluded that government intervention is necessary to promote energy efficiency and articulated well the purpose and the content of energy efficiency policy. Energy efficiency policy needs to highlight the link with the existing national energy and environmental policies. According to Zhang *et al.* (2017), energy efficiency policy should be supported by a framework that provides the legal basis and the funding mechanism needed for implementing an energy efficiency strategy.

- **Lack of clear electricity conservation targets**

This barrier was rated important with a combined rating score of 59%. OECD/IEA (2010) provided that unclear electricity conservation targets are often ignored due to the lack of specificity. To

avoid this, governments should have clearer and sharper electricity conservation targets. Clear targets would make policy coherence part of the international framework for the SDGs.

With the absence of documented standardised procedures for energy audit and electricity conservation measurement and verification, it is difficult to evaluate the effects of energy efficiency projects (South Africa, 1998:81; Shen *et al.* 2012:17). ISO 50001 standard is seen as the best practice identified in the literature that refers to measures needed to improve energy efficiency. To reduce energy intensity, China used ISO 50001 as an energy efficiency standard to support the diffusion of energy-efficient appliances in the residential sector (Zhang *et al.* 2017).

- **Lack of regulatory framework and legislation for energy efficiency at the municipal level**

This barrier was rated important with a combined rating score of 50%. The South African government has put in place several policy and regulatory interventions that aim to promote energy efficiency (DEFF, 2020:24). However, respondents perceived the current regulatory and institutional environment as a significant barrier to the deployment of energy efficiency initiatives. In this regard, they mentioned that a new legal and regulatory environment is required, based on more electricity market principles and regulatory improvements. Respondents also indicated that the regulatory policies should be set at the national level, while the implementation thereof, including compliance monitoring and enforcement, should take place at the regional or municipal level.

Experts expressed that the existence of legislation is a necessary and often a sufficient factor in the implementation and improvement of energy efficiency. The experts indicated that the regulatory framework in South Africa supports and enable investment in energy efficiency. Although more work still needs to be done to expand the EEDSM programme, the experts were at least content that there is a legislative provision that allows for energy efficiency investments.

- **Lack of leadership from top executives to enhance energy efficiency**

This barrier was rated important with a combined rating score of 41%. In the existing literature, Lihalo (2010) examined the impact of leadership on the implementation of energy efficiency. According to Lihalo (2013:10), a lack of leadership from top executives arises when the top managers and leaders do not commit themselves to the process of strategy implementation in an organisation.

- **Energy manager lacks authority and influence**

This barrier was rated important with a combined rating score of 45%. According to Singh and Lalk (2006:293), the lack of dedicated energy managers who are experienced in energy efficiency could have an impact on the organisation not realising their energy efficiency potentials, as energy managers are expected to monitor electricity usage and design energy efficiency programs that reduce electricity-related costs. Energy managers are also expected to perform audits to evaluate electricity use, efficiency, and costs. Brunke *et al.* (2014) and Christoffersen *et al.* (2006:520) pointed out that there is a strong link between energy managers and the industry adopting energy efficiency policies.

- **Lack of political support to improve energy efficiency**

This barrier was rated important with a combined rating score of 45%. Langlois-Bertrand *et al.* (2015) demonstrated how political polarisation can negatively affect the adoption of energy efficiency. The study demonstrated that more politically conservative persons were less in favour of energy efficiency investment than those who were politically liberal.

4.4.3.2 Unimportant governance barriers

- **Municipality's inadequate capacity to enforce mandatory measures and regulations**

This barrier was rated unimportant with a combined rating score of 41%. The South African Municipal by-laws have not been developed to include the regulation of energy efficiency. Currently, the only existing regulation on energy efficiency is the National Energy Efficiency Strategy.

- **Lack of regulatory guides to enforce and monitor strategic outputs**

This barrier was rated unimportant with a combined rating score of 45%. The absence of an energy efficiency regulatory framework gives rise to several areas of concern about achieving the NDP 2030 energy targets. Energy efficiency regulation is necessary to reduce electricity consumption and stimulate electricity conservation.

- **Lack of effective measurement and verification (M&V) protocol and implementation for documenting electricity savings in municipalities**

This barrier was rated unimportant with a combined rating score of 36%. Electricity-saving measures include a range of activities aiming to improve energy efficiency. This has an important impact on decision-making that involves the energy efficiency investment. With the absence of documented standardised procedures for energy audit and electricity conservation measurement and verification, it is difficult to evaluate the effects of energy efficiency projects (South Africa, 1998:81; Shen *et al.* 2012:17).

- **Lack of metered or recorded electricity consumption and conservation**

This barrier was rated unimportant with a combined rating score of 50%. Simply implementing electricity management systems alone will not bring substantial savings. Fawkes (2005:22) provided that a successful electricity management system should have an organisational plan for implementing and monitoring specific electricity management programs. Organisations need to know how to extract and analyse data and act on the information.

- **Political interference in electricity management programs**

This barrier was rated unimportant with a combined rating score of 36%. Political involvement in energy efficiency provides politicians with the information needed to make policy decisions and includes engagements that provide regulators with important information regarding the impacts of energy efficiency regulatory decisions and hold regulators accountable for their decisions. Langlois-Bertrand *et al.* (2015:6) provided that political involvement can turn into political interference that violates the procedures that seek to foster the implementation of energy efficiency. Political interference may make municipalities incur uneconomical costs when political appointments are made instead of a qualified person to manage the implementation of energy efficiency (Winkler, 2006).

- **High levels of corruption impede the financial support to energy efficiency projects**

This barrier was rated unimportant with a combined rating score of 64%. This finding is contrary to the finding made by Ozturk *et al.* (2019) in the study of the relationship between corruption and the implementation of energy efficiency in 60 countries categorised by lower middle income, upper middle income, and high income. The results showed that the lower the corruption is, the more the energy efficiency for all income group economies. The study recommended that all these countries should increase their corruption control to enhance and improve energy efficiency.

According to the experts, the South African municipalities are confronted with high levels of corruption and poor financial management. A lack of transparency in energy efficiency decisions as well as a lack of an effective legal system to reduce corruption was cited as the drivers for the high corruption levels. These respondents pointed out that these factors have a direct impact on the internal funding of energy efficiency projects. The high cost of energy efficiency technologies also puts a damp on financing the energy efficiency programs. Moreover, corruption reduces environmental policy stringency.

- **Lack of coordination and cooperation between the stakeholders, i.e., the municipal, provincial, and national sphere**

This barrier was rated unimportant with a combined rating score of 68%. Section 10(1)(c) of DoRA deals with the transferring of funds by the payment schedule determined by section 21. Expert respondents indicated that the Department of Energy is having challenges in complying with this section of the law due to municipalities not requesting funds according to the payment schedule. Municipalities are said to not comply with the requirements of sections 12(2) and 12(7) of DoRa, which require municipalities to submit monthly, quarterly, and annual evaluation reports, making it difficult for the Department of Energy to comply with the Act.

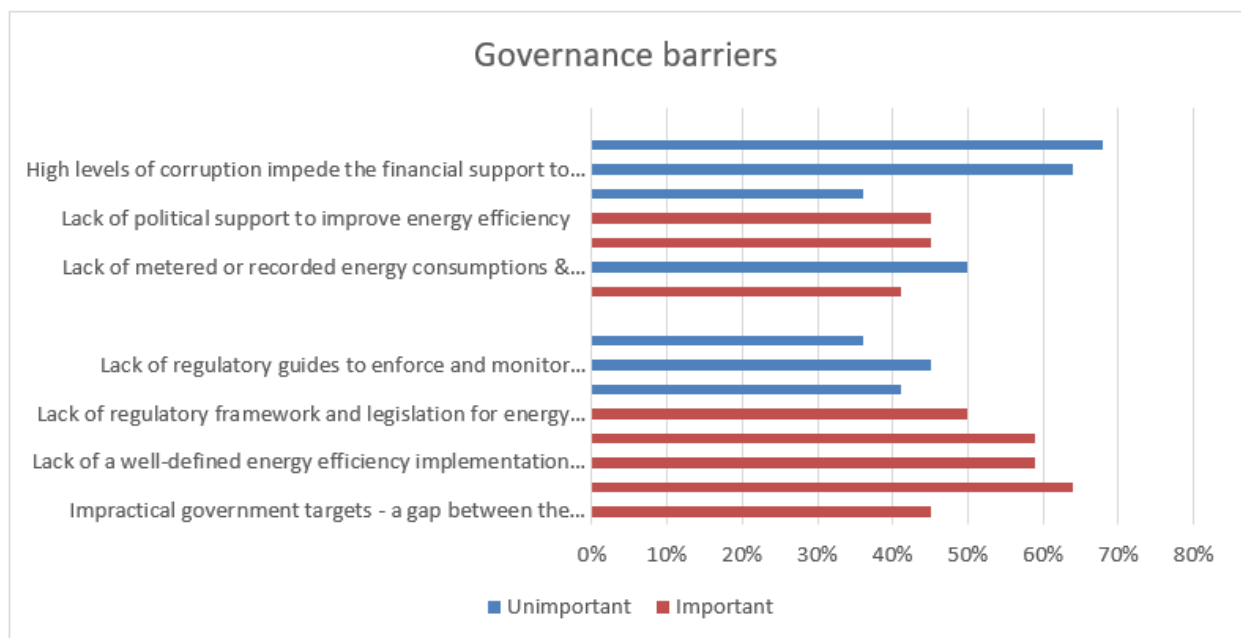


Figure 4-8: Graph of governance barriers

Municipalities have been criticised for not submitting their evaluation reports to the Department of Energy on regular basis, not using the available payment schedule when requesting funding, delays in the signing of the contract, and lack of capacity and competence to minister the EEDSM programme, and not implementing energy efficiency projects as agreed in the contracts. To mitigate these challenges, the experts suggested that municipalities should be supported in planning and capacity-building development and monthly reporting. The Department of Energy's Regional Energy Officers should assist municipalities with planning, implementation, and monitoring of energy efficiency projects.

Figure 4-9 provides the barrier taxonomy for the implementation of energy efficiency in specific South African Municipalities. The taxonomy presents the barriers that were cited to be important by the respondents.

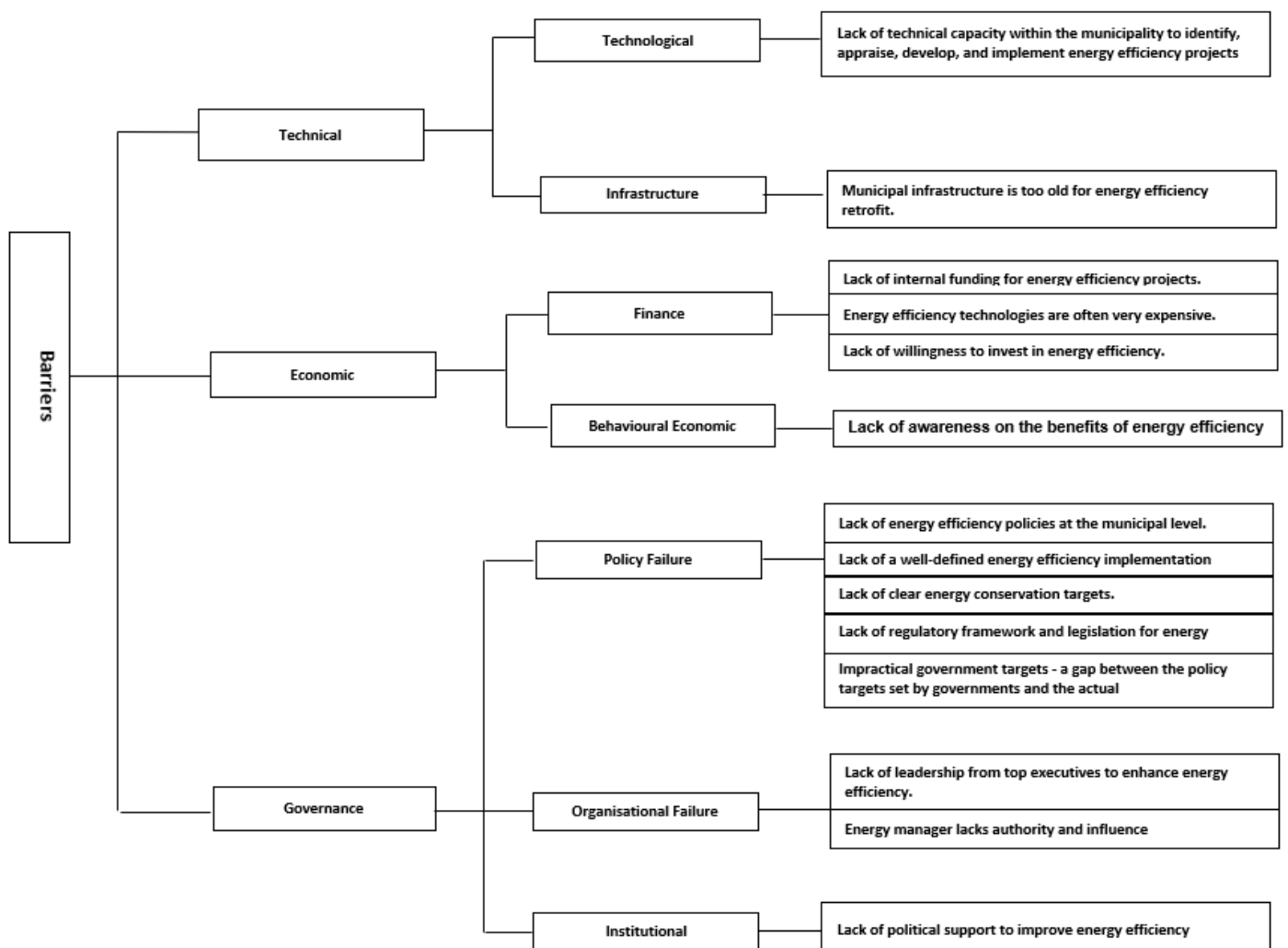


Figure 4-9: Taxonomy of important barriers for specific South African Municipalities

4.5 Results related to Objective 3: Recommendations

Many municipal respondents expressed their interest in receiving the results of the analysis. Based on the received responses and follow-up interviews with the municipal and expert respondents, the measures to overcome barriers to energy efficiency are discussed. Table 4-8 provides a literature summary of energy efficiency Improvement.

Table 4-8: Literature summary of the recommendation to overcome energy efficiency

Theoretical Barriers	Literature
Technical Barrier	• Municipal water and wastewater facilities are typically the largest consumers of electricity in municipal operations. Improving the energy efficiency of equipment and operations at water and wastewater facilities can reduce electricity costs, and GHG emissions, and increase treatment efficiency (Thollander <i>et al.</i> 2010). • Support energy efficiency research and development (Schleich, 2011:21).
Economic Barrier.	• Although energy efficiency technology is expensive compared to the conventional alternatives, utility bill savings over the life of the efficient product can offset the initial costs (Singh and Lalk, 2016). • Energy efficiency requires the investment of capital (Covary and Aversch, 2013). • Mechanisms to capture the opportunities for energy efficiency delivery systems need to be created or strengthened (UNECE, 2015). • <i>Awareness</i> - The high level of awareness created by a stimulant, such as an advertising campaign by a technology manufacturer, is an important driver for energy efficiency (Singh and Lalk, 2006:294). • <i>Values and Culture</i> - An organisation's culture may be seen as the sum of an individual's values. The values of workers who influence the organisation, such as executives' values, may have more impact on the organisation's culture than workers in 'lower status' positions (Sorrell <i>et al.</i> 2000). • Municipalities should explore public-private partnerships as that would help in alleviating the burden of capital requirement ((DoE, 2018). • Raise awareness of electricity consumption and related aspects of energy efficiency among users (Seetharaman <i>et al.</i> 2019).
Governance barriers	• Energy efficiency requires "soft" elements like public policy support, education, awareness, and innovative financing tools (Singh and Lalk, 2016). • Energy efficiency policies must be regularly reviewed to ensure proper implementation (Aboltins and Blumberga, 2019:195).

	• Environmental regulations can drive internalised environmental costs which can make energy efficiency investments more financially attractive (Singh and Lalk, 2016). • Encourage energy auditing and energy assessment (Bilous, 2020:19). • Development of energy efficiency best practices, and information on norms and standards (Filippo, 2012:41).
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4.5.1 Technical barriers

Energy efficiency improvements are most likely to be successful if there are individuals with real ambitions within top management (Lihalo, 2013:10). To address the barriers of lack of technical capacity in municipalities, it is recommended that there is at least one fully trained staff member at a management level who understands the importance of energy efficiency. Expert respondents suggested that municipal staff members should be trained on the implementation and the maintenance of electricity management systems, and particularly on being skilled in energy efficiency audits. The dearth of these critical skills in under-resourced municipalities has led to poor infrastructure planning.

Municipal buildings and services consume the largest amount of electricity. Water and wastewater treatment makes use of old equipment such as pump motors and drivers. By converting to energy-efficient equipment, municipalities can save on their electricity bill and decrease their maintenance cost. Lighting is also one of the major causes of high electricity consumption in municipal buildings.

Advanced lighting systems such as LED lights may greatly reduce electricity consumption. A large amount of electricity is wasted in the cooling and heating of municipal buildings. The experts recommended the use of geothermal HVAC systems which has the potential to reduce the amount of electricity consumption by 50% for cooling and heating system. The experts suggested the use of larger diameter electrical cables from the distribution board for wiring the new building. These large cables have high initial costs that would lead to electricity savings within a short time.

4.5.2 Economic barriers

As noted from the literature review and discussions with the municipal and expert respondents, economic barriers are regarded as the highest hindrance to energy efficiency implementation.

The experts pointed out the importance of market-based instruments (MBIs) for the promotion and improvement of energy efficiency. MBIs are policy instruments that use markets to provide incentives to municipalities to reduce or eliminate negative environmental impacts. It is observed that the South African government (both national and municipalities) needs to address and manage the existing market failures by increasing the EEDSM financial incentive by providing easily accessible funding and increased capacity at the municipal level. Municipalities are expected to use the incentive grants for their intended purposes. Both the literature and the experts agree that the successful implementation of energy efficiency in municipalities will help reduce the operational cost of electricity production.

4.5.3 Governance barriers

The research findings reveal that the EEDSM policy and the NEES must be intensified to provide quick power system relief, reduce greenhouse gas emissions, reduce bureaucracy, reduce increased electricity demand, and accelerate the approval of energy efficiency projects. This can be done through regulations, financial incentives, and institutional governance structures. Respondents strongly believe that electricity management practices for energy efficiency should be implemented under a common framework of an energy efficiency policy. One of the challenges municipalities faces in implementing energy efficiency projects is effectively articulating and quantifying the positive socio-economic benefits that energy efficiency produces.

4.6 Chapter summary

Based on the objectives of the study, this chapter began by providing a discussion on the demographic of the participants. To achieve this objective, a description of the demography of the study area including the participants was presented. The Municipal EEDSM programme has been developed to provide municipalities with support and financial assistance to bridge the energy efficiency gap. Furthermore, the EEDSM programme intends to build technical capacity through energy efficiency training and develop methods for changing organisational and behavioural aspects of municipalities.

The second objective of the study evaluated barriers that hinder the successful implementation of energy efficiency in specific South African municipalities. The research classified barriers into three categories, and fourteen theoretical barriers, i.e., technical (with two important barriers), economic (with four important barriers) and governance (with eight important barriers).

At the municipal level, lack of technical capacity and ageing infrastructure was rated as the important technical barriers. For economic barriers, the cost of energy efficiency technology, lack of internal funding, lack of willingness to invest in energy efficiency and lack of awareness of the benefits of energy efficiency were rated as the most important barriers that affected the specific municipalities. The important governance barriers for municipalities included the lack of practical energy efficiency and electricity conservation targets, lack of energy efficiency policies, lack of regulatory framework and legislation, lack of well-defined energy efficiency implementation framework, lack of leadership from top executives, lack of effective energy manager, and the lack of political will to drive the energy efficiency initiatives.

The third objective of the study intended to provide a discussion on the recommendation of overcoming the barriers to energy efficiency based on best practices. In general, the significant recommendation made by the study is that energy efficiency should be prioritised if South Africa wants to achieve their international obligation of reducing climate change effects. Energy efficiency should be emphasised in the energy policy development and implementation throughout South African municipalities. The National Energy Efficiency Strategy roadmap must be revised to include achievable targets for municipalities. Training in measurement and verification, energy audits, and monitoring must be strengthened.

CHAPTER 5 DISCUSSION AND CONCLUSION

5.1 Introduction

The following chapter discusses a summary of the research findings. It links the surveyed literature presented in Chapter 3 and the data analysis presented in Chapter 4. The implementation of energy efficiency initiatives might at first seem quite straightforward, however, putting strategies into action is a far more complex and difficult task. The respondents demonstrated that energy efficiency is more complex. The research findings confirmed some of these barriers to the implementation of energy efficiency in specific South African municipalities.

5.2 Discussion

From the data analysis presented in Chapter 4, numerous findings are made. The most important outcome of the research was to describe and categorise barriers to improving energy efficiency in specific South African municipalities. Based on the results presented in Chapter 4, the barriers were grouped into technical, economic and governance, as seen in Figure 5-2.

Objective 1: Evaluate the status of energy efficiency initiatives in specific South African municipalities

The first research objective investigated the status of energy efficiency initiatives in specific South African municipalities. It was seen that South Africa is a high energy-intensive country. EEDSM programme support municipalities across South Africa in their efforts to reduce electricity use by optimising their electricity consumption. Municipalities receive a grant from the Department of Energy for the implementation of energy-efficient technologies. The energy efficient-technologies ranges include traffic lights, streetlights, building lights, HVAC systems, and water service infrastructure. With the implementation of the EEDSM programme municipalities are expected to reduce the greenhouse gas emissions in their operation and reduce users' electricity bills.

The amended National Building Regulations requires all new buildings and extension to comply with the electricity usage in buildings provisions to reduce greenhouse gas buildings. SANS 10400-XA is the standard for electricity usage in buildings and it is established as the benchmark for the environmental sustainability of buildings.

Objective 2: Characterise the barriers that hinder energy efficiency by evaluating the implementation of the Energy Efficiency and Demand Side Management Programme in selected municipalities.

To classify barriers the study followed the approach proposed by Sorrell *et al.* (2000) The research findings showed that municipalities are battling to successfully implement measures that improve energy efficiency. This is partly due to the complex nature of energy efficiency. Apart from Metropolitan municipalities who have shown significant improvement in their electricity management through the formation and implementation of energy efficiency policies and energy audits, District and Local municipalities are still way behind.

The research classified barriers into three categories, and fourteen theoretical barriers, i.e., technical (with two important barriers), economic (with four important barriers) and governance (with eight important barriers). The study findings indicate the lack of technical and human capacity and skills to conduct electricity consumption surveys as the most socio-technical barrier faced by municipalities. All the municipalities that were sampled, irrespective of size have indicated “capacity” as a critical barrier. The need for capacity building that includes up-skilling of municipal staff and the recruitment of energy managers in technical departments is important if municipalities are to achieve the SDG and NDP targets. The old and ageing municipal infrastructure that simply cannot withstand the demand has been cited as the barrier affecting municipalities to improve their measure of energy efficiency. Many municipalities do not conduct energy audits to analyse electricity usage and consumption.

In general, the experts agreed with the research findings. The lack of technical capacity by municipalities to identify, appraise, develop, implement, and maintain energy efficiency projects was cited as one of the major technical barriers to the implementation of energy efficiency initiatives. Lack of experience and specialists who can identify barriers and assess the degree of impact through effective measurement and verification protocols, primarily, due to the outsourcing of ESCos was also a high market-based barrier raised by the experts. A general lack of electricity consumption data from municipalities is also raised a serious market-based barrier.

Municipalities are further confronted with a lack of knowledge of available incentives, due to market failures. The experts have noted sufficient partnering of municipalities with key stakeholders, including the national government and other municipalities which has improved

cooperative governance. Even though the EEDSM programme has been hailed as a good step in improving energy efficiency, the experts criticise it for not setting requirements for capacity, skills, or qualifications for those who implement and manage the EEDSM projects. It is a common belief among the expert respondents that the South African energy efficiency incentives must be reformulated and improved in line with South Africa's national policy objectives.

Many municipalities are facing huge costs associated with the breakdowns of their water and wastewater treatment. As energy efficiency technology continues to evolve, it is crucial that municipal infrastructure remain fit for purpose and planned energy efficiency upgrades provide a prime opportunity to achieve this. Municipalities are, however, upgrading old infrastructure technologies to new ones that increased energy efficiency, examples include retrofit to lighting and upgrading water and wastewater pumping technology.

Market-Based Instrument such as the Municipal EEDSM programme is taunted as an initiative to reduce the economic barriers that exist due to market failures. Although EEDSM provides funds for retrofitting existing infrastructure to become more energy-efficient, municipalities have limited knowledge on how EEDSM may be used to invest in energy-efficient infrastructure. Awareness, a non-market failure was identified as a barrier. Most municipalities have not conducted energy surveys and are therefore unaware of the benefits of improved energy efficiency. Furthermore, a lack of access to capital is considered an energy efficiency barrier. In some municipalities, energy efficiency has a low priority compared to other initiatives that seek to reduce greenhouse gas emissions.

Governance of energy efficiency includes legislation, funding mechanisms and institutional arrangements which work together in the implementation of energy efficiency policies and strategies. Command-and-control environmental regulations require municipalities to install technologies that will reduce electricity demand. However, command-and-control environmental measures often fail to achieve the desired outcome. Deployment of voluntary instruments like SANS ISO 50001 Energy Management Systems are often deployed in parallel with the law to support the legal instruments and measures to bring the required changes.

In general, there is a positive correlation between the perception of the experts and the municipal respondents on the importance of a regulatory framework for energy efficiency. However, it is worth noting that the experts were concerned about the lack of a regulatory framework that deals

directly with municipalities on energy efficiency investment as this will provide little support for municipalities should the government decide to halt the DoRA-funded EEDSM. A lack of enforcement was also raised as a concern. The dependence of municipalities on grant funding was raised as a risk facing the implementation of energy efficiency. To ensure that energy efficiency remains sustainable, municipalities should generate their income for small projects that don't require a large amount of money.

Objective 3: Identify potential options for addressing the barriers to implementing an energy efficiency initiative

According to the experts, the national government is expected to increase the EEDSM grant incentives and increase capacity at the municipal level. Municipalities are expected to use the incentive grants for their intended purposes. EEDSM policy and the NEES must be intensified to provide quick power system relief, reduce greenhouse gas emissions, reduce bureaucracy, reduce increased electricity demand, and accelerate the approval of energy efficiency projects. Energy efficiency improvements are most likely to be successful if there are individuals with real ambitions within top management.

To address technical barriers, it is recommended that there is at least one fully trained staff member at a management level who understands the importance of energy efficiency. Municipal buildings and services consume the largest amount of electricity. The experts recommended the use of geothermal HVAC systems which has the potential to reduce the amount of electricity consumption by 50% for cooling and heating system.

To address economic barriers, it is recommended that municipalities should take advantage of the available incentive grants from the national government. To address governance barriers, it is recommended that the National Energy Efficiency Strategy roadmap must be revised to include achievable targets for municipalities. Training in measurement and verification, energy audits, and monitoring must be strengthened.

5.3 Conclusions

According to Joyner *et al.* (2018), in concluding a dissertation, the researcher should evaluate the research aims and objectives. The primary aim of this research was to describe and categorise barriers that hinder the implementation of energy efficiency in South African municipalities. This

study has confirmed the findings of Sorrell *et al.* (2000) which described and classified barriers to energy efficiency.

Although Sorrell *et al.* (2000) and other authors developed taxonomies for the barrier to energy efficiency, it remains insufficient for the context of South African municipalities. Therefore, there was a need for research to relook at the barriers affecting municipalities to implement energy efficiency that is relevant and applicable to the sector. When implemented correctly, the findings of this study will set the precedent for creating research that contributes to the rethinking of energy efficiency barriers

In achieving Objective 1, it was realised that energy efficiency initiatives play a role in reducing the energy intensity of the country. The improvement in energy efficiency during this period was due to the different energy efficiency programmes mentioned in the National Energy Efficiency Strategy.

Objective 2 of the study intended to describe the barriers to the implementation of energy efficiency. The study of barriers to energy efficiency was developed to include the relevant barriers observed in the literature. The barriers were classified into three categories, viz., technical, economic and governance barriers.

Although not explicitly defined in the literature, this study also aimed at understanding the drivers that contribute to the adoption of energy efficiency initiatives amongst municipalities. The presented taxonomy will help in the analysis of the causal relationship between drivers and barriers and further assist in the development of appropriate response measures. Proponents of energy efficiency like Singh and Lalk (2006) pointed to the drivers of energy efficiency as the important component to understand the barriers to energy efficiency.

Objective 3 intended to provide recommendations on measures to be taken to reduce the barriers. This study is expected to help in the reduction, removal, or avoidance of these barriers. An understanding of the barriers to energy efficiency is crucial for municipalities that want to develop an effective electricity management system and for future energy policies that will help municipalities to achieve their electricity objectives.

Expert respondents indicate stricter energy efficiency standards and training and awareness programmes as some possible remedies for the improvement of energy efficiency. The experts

indicate that energy audits should be mandatory for all municipalities. Technical expertise should be improved by adopting the electricity management systems SANS 50001. The legislation on energy efficiency should be improved and updated.

Through the EEDSM programme, municipalities have been implementing projects to reduce energy intensity. The most popular project among the municipalities is the retrofit of office building lighting, where old light technologies were replaced with electricity-saving LED lighting. The awareness of the energy efficiency policies (international and national) among the respondents is quite good. Most municipalities are aware of the 2030 energy efficiency targets mentioned in the SDGs and the NDP. Although most municipalities have not set their energy targets as described by the NEES, measures are being taken to include targets in their operations.

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Annexure A: Respondents to the study

Interviewees	Position	Experience	Questionnaire/Interviews
Respondent 1	Snr Manager: Electrical Services	8	Completed Questionnaire + 1 interview
Respondent 2	Chief Energy Technician	10	Completed Questionnaire + 1 interview
Respondent 3	Chief Engineer - Technical Services	2	Completed Questionnaire + 1 interview
Respondent 4	Energy Efficiency Manager	7	Completed Questionnaire + 1 interview
Respondent 5	Intern Engineer - Technical Services	2	Completed Questionnaire + 2 interviews
Respondent 6	Manager: Infrastructure and Technical Services	3	Completed Survey + 2 interview
Respondents 7	Acting Manager: Electrical Services	6	Completed Survey + 3 interview
Respondent 8	Executive Director - Technical Services	3	Completed Survey + 2 interview
Respondent 9	Assistant Manager - Technical Services	3	Completed Questionnaire + 1 interview
Respondent 10	Director Energy	6	Completed Questionnaire + 1 interview
Respondent 11	Snr Manager: Electrical Services	8	Completed Questionnaire + 1 interview
Respondent 12	Executive Director - Technical Services	13	Completed Questionnaire + 1 interview
Respondent 13	Director -Technical Services	8	Completed Questionnaire + 1 interview
Respondent 14	Director - Technical Services	6	Completed Questionnaire + 1 interview
Respondent 15	Manager Electrical	3	Completed Questionnaire + 1 interview
Respondent 16	Electrical Engineer	2	Completed Survey + 2 interview
Respondent 17	Manager Electrical	9	Completed Questionnaire + 1 interview
Respondent 18	Superintendent Operations and Maintenance	3	Completed Questionnaire + 1 interview
Respondent 19	Technical Services Manager	6	Completed Questionnaire + 1 interview
Respondent 20	Manager - Environmental Management	3	Completed Questionnaire + 1 interview
Respondent 21	Snr Manager: Technical Services	10	Completed Questionnaire + 1 interview
Respondent 22	Division Head - Technical Services	17	Completed Questionnaire + 1 interview
Average	-	6.3	-

Experts

Interviewee	Position	Education	Experience (Years)	Questionnaire/Interviews
Respondent 1	Researcher/Academic	PhD	12	3 x Interviews
Respondent 2	Engineer/Government	Masters	5	2 x Interviews
Respondent 3	Engineer/Consultant	Masters	8	2x Interviews
Respondent 4	Engineer/Financier	Bachelors	17	2x Interviews
Average	-		10.5	-

Annexure B: Taxonomy of barriers from various sources (inspired by Sorrell *et al.* 2000 and 2004)

Theoretical barriers	Literature
Technical barriers	
Technological barriers	• Limited energy efficiency technologies (Reddy, 1991:18; South Africa, 1998:10). • Lack of technical capacity to identify, appraise, develop, and implement energy efficiency projects (South Africa, 1998:85; UNIDO, 2006:25; DoE, 2018:14; Schleich, 2011:21; Aboltins and Blumberg, 2019:195; Shen <i>et al.</i> 2012:21). • The fast turnover of new EE technology risks firms' EE measures quickly becoming obsolete (DoE, 2018:19). • Lack of diversified technology offerings from ESCos (Shen <i>et al.</i> 2012:21) • Insufficient local capacities for identifying, developing, implementing, and maintaining energy efficiency investments (OECD/EIA, 2010:35; DoE, 2018:19). • Lack of adequate framework for research and development (Seetharaman <i>et al.</i> 2019:4; Schleich, 2011:21). • Efficiency investments represent a higher technical or financial risk than other types of investment (Sorrell <i>et al.</i> 2004:30). • Lack of experience and specialists who can identify barriers and assess their degree of impact (Bilous, 2020:20). • lack of reliable measurement equipment and baseline data (Shen <i>et al.</i> 2012:22) • Lack of effective measurement and verification protocol and implementation for documenting electricity saving s (Shen <i>et al.</i> 2012:17). • Lack of a centralised energy efficiency portal and comprehensive energy efficiency sector data for detailed Monitoring and Evaluation (DoE, 2018:9). • Lack of energy innovation system (UNSD, 2019:83) • Technological defaults (Singh and Lalk, 2016:290)
Economic barriers.	
Market failures	• lack of reliable data on electricity conservation targets (DoE, 2016:460) • Lack of knowledge of available incentives for end-use efficiency measures can lead to missed opportunities. (DoE, 2018:15). • Lack of knowledge by the lenders about EE investments (Longarela-Ares <i>et al.</i> 2020:4). • Lack of Local procurement due to a lack of skills (DoE, 2018:14) • Limited availability of appropriate financial incentives to accelerate the implementation of programmes such as the Solar Water Heaters initiative (DoE, 2018:13). • The total funding allocation granted has been declining due to tighter fiscal constraints and poor-performing municipalities (Kruger and Tait, 2015:12). • Hidden costs (to the observer!) include overhead costs for management, disruptions to production, staff replacement and training, and the costs associated with gathering, analysing, and applying information (Schleich, 2007:88). • Utility monopoly of production or imperfect competition (Singh and Lalk 2016:289). • Market organisation and price distortions that prevent consumers from appraising the true value of energy efficiency (OECD/IEA: 2010:35) • Implementer of EE does not provide sufficient information to the market, which results in the consumer making ill-informed decisions (Sorrell <i>et al.</i> 2004:4). • A lack of skills in the energy efficiency market remains a challenge (DoE, 2018:15) • Insufficient partnering with key stakeholders leads to a lack of cooperative governance that is essential for the coordinated implementation of activities and clearly defined responsibilities (DoE, 2018:15). • Municipal EEDSM programme sets no requirement in terms of the capacity, skills, or qualification for those who manage and implement EEDSM projects. Many municipal staff do not know where to start and seek technical assistance from suppliers or external consultants (USAID, 2020:6). • Lack of substantial data about the size of the national energy efficiency market (Greencape, 2015:8). • Lack of effective market structures and finance to proceed with programmes such as the SWH programme (DoE, 2018:18).

Theoretical barriers	Literature
	Gap for supporting new projects (DoE, 2018:18).
Economic barriers	
	- Lack of support for smaller initiatives (DoE, 2018:18). - Lack of detailed data in analysing energy EE trends in the commercial and public sector, making it difficult to identify and separate structural effects (South Africa, 2015:28). - Available data on electricity consumption tends not to be disaggregated (South Africa, 2015: iii). - Data on activity levels measured in physical units is practically non-existent (South Africa, 2015: iii). - Lack of information on energy efficiency opportunities may lead to cost-effective opportunities being missed (Schleich, 2007:88). - lack of information on the technical and technological parameters of products and technologies (Bilous, 2020:17). - Lack of information and awareness of the potential for energy efficiency (UNIDO, 2006:25). - Limited delivery and implementation capacity among the public and private sectors implies a need to create dedicated public and private entities for scaling up energy efficiency (DoE, 2018:14) - Lack of industry initiatives to emphasize electricity management as an integral part of total management systems (UNIDO, 2006:25). - Lack of sufficient data collection and management for electricity use (DoE, 2018:15). - While South Africa has several policies, regulations, and initiatives in place to scale up EE behaviour and technologies, these form a "scattered environment" that lacks the coherency and alignment required to facilitate the buy-in and increased investor (Covary and Aversch, 2013:592). - The quality of information disseminated to the public (Covary and Aversch, 2013:592). - Low diffusion rates of EE technologies limit the potential for adoption by firms (Singh and Lalk, 2016:290) - no centralised institutional structure within the municipality that is responsible for internal electricity use and, therefore, no coherent approach to monitoring and management of electricity use (National Treasury, 2013:98)
Financial barriers	- low price of energy in South Africa is one of the significant barriers to investment in energy efficiency in the country (de la Rue du Can <i>et al.</i> 2013:3) - Lack of internal funding for energy efficiency (Shen <i>et al.</i> 2012:20). - Lack of financial and fiscal drivers for energy investments (Shen <i>et al.</i> 2012:20). - High transaction costs, i.e., project development costs are high relative to potential electricity savings (Schleich, 2000:13; OECD/EIA, 2010:35; Sorrell, 2004:9; Longarela-Ares <i>et al.</i> 2020:4; DoE, 2018:15). - EE technologies are generally more expensive than traditional energy-intensive technologies (OECD/EIA, 2010:35). - Funds might not be readily available for investment in the EE project (Singh and Lalk, 2016:289) - A technology might only be cost-effective for a proportion of users of a certain class (Singh and Lalk, 2016:290) - Electricity costs are too low to provide economic incentives (UNECE, 2018:13). - Lack of access to low-cost capital or credit (Gardner <i>et al.</i> 2014:31; Ürge-Vorsatz <i>et al.</i> 2007:2; Sorrell <i>et al.</i> 2004:105). - Financial institutions' lack of understanding of project cash flow (Kim and Shcherbakova, 2011:13). - Subsidies are inadequate for the project (Sorrell <i>et al.</i> 2003:11). - Lack of finance to continue with the investment (Aboltins and Blumberga, 2019:197). - Inadequate fiscal incentives (Seetharaman <i>et al.</i> 2019:7);

Theoretical barriers	Literature
Economic Barrier	
Behavioural economics	• Consumers don't understand how to use energy efficiently to preserve the environment (South Africa, 1998:98; DoE, 2018:14; Jangali and Nagesha, 2017:2; DGIP, 2016:90). • Lack of consumer awareness and understanding or limited information on the knowledge and benefits of energy efficiency (DoE, 2018:14). • Lack of broad public awareness of energy efficiency that will require large campaign rollouts to educate the public on improved energy efficiency (DoE, 2018:14). • Lack of education (Sorrell, e al., 2003:6; Kim and Shcherbakova, 2011:8). • Lack of consumer engagement and trust (Dunphy <i>et al.</i> 2018:6). • Lack of understanding of the complexity of electricity-saving projects (Shen <i>et al.</i> 2012:20). • Lack of awareness about the environmental and health risks resulting from their electricity usage (South Africa, 1998:91) • Consumers are of the view, that even though electricity costs are rising the cost of implementing energy efficiency measures relative to the cost of energy, is still high (Padachi, 2014:43). • The awareness barrier also relates to a lack of knowledge regarding the positive impact adoption of efficient technologies can have on the business case for operators (Minetto <i>et al.</i> 2018:424). • Public resistance and opposition due to lack of awareness (Seetharaman <i>et al.</i> 2019:4). • Consumers want to avoid change in their environment and retain the status quo (Schleich, 2000:13). • Low confidence in projected energy and cost savings that will be achieved. (Iea-isgan, 2015). • Due to the volatility of the South African Rand on the currency market, consumers find it difficult to appropriately budget for the import of energy-efficient technologies (Padachi, 2014:44). • Energy efficiency measures are often perceived as disrupting production processes (Padachi, 2014:43) • Consumers don't trust the government as the implementer of EE (Thollander <i>et al.</i> 2010:54) • Operational costs are more important than environmental issues (Sorrell <i>et al.</i> 2004:30). • Employee's attitude and capabilities are the key drivers for the successful EE implementation (Sorrell, <i>et al.</i> 2004:28). • Industry has misconceptions about EEDSM and is reluctant to change any of their existing processes (Padachi, 2014:25). • There is a misconception that a change to EE will bring about disruptions and a lack of productivity (Padachi, 2014:25). • Underlying fears that previous incompetence may surface regarding neglected electricity saving s opportunities. (Padachi, 2014:25). • organisational culture leads to neglect of energy/environmental issues (Sorrell <i>et al.</i> 2004:5). • Lack of information related to electricity consumption, electricity-saving potential, economic and environmental benefits, lack of credible information, and lack of understanding of complex information (DGIP, 2016:90).
Governance barriers	
Policy failures	• Gap between policy targets and implementation (Jangali and Nagesha, 2017:3). • EE policy incentives must be reformulated and improved in line with South Africa's national policy objectives (DoE, 2018:2). • Lack of supporting guidelines for the implementation of green financing policies (Shen <i>et al.</i> 2012:17) • Since NEED, no follow-up on legislation, no yardstick by which progress could be monitored, and no publication of estimates in energy efficiency trends (Sebitosi, 2008:1592). • Lack of long-term policy mechanism and effective policy design (Shen <i>et al.</i> 2012:17; Seetharaman <i>et al.</i> 2019:8).

Theoretical barriers	Literature
	lack of a cohesive program which is underpinned by unambiguous policy and regulations (Covary and Aweresch, 2013:591)
Governance barriers	
	- Limited public commitment and prioritization of policy and regulations to enforce EE (DoE, 2018:14) - Lack of a system capable of monitoring and overseeing policy compliance (Shen <i>et al.</i> 2012:17). - Lack of implementation and enforcement (DoE, 2018:15) - Tax structure that is not streamlined to other sectors (DoE, 2018:18). - Subsidies in the energy sector may result in a rebound effect about energy efficiency measures whereby EE improvements decrease the marginal cost of energy services, thereby increasing demand and inducing less-than proportional reductions in electricity use (DoE, 2018:18). - Technology and institutional change mean that EE policies must be kept up to date with contemporary technologies, or else risk becoming irrelevant (DoE, 2018:16). - lack of clarity and follow-through on policy announcements and targets and plans (Covary and Aweresch, 2013:592). - Current Municipal EEDSM programme does not originate in any policy (Kruger and Tait, 2015:9). - DoRA funding requires technical audits of electricity savings required by the DoE. These are generally regarded as overly onerous for institutions that already lack capacity (Kruger and Tait, 2015:16). - EEDSM programme developed as a crisis response has also lacked a clear strategy and long-term vision, potentially impacting the longer-term sustainability of energy-efficient activities beyond its lifetime (Kruger and Tait, 2015:17). - Lack of good data is a major weakness in the energy policy-making process (South Africa, 1998:84) - No clearly articulated incentives to save energy or implement electricity-saving programmes (National Treasury, 2013:98).
Regulatory	- Fragmentation in energy law (Langlois-Bertrand <i>et al.</i> 2015:7). - Lack of regulatory framework and legislation for energy efficiency (Winkler, 2006:84). - Electricity tariffs that discourage EE investment (such as declining block prices) (OECD/IEA, 2010:35) - lack of political backing of measures and legislation to improve energy efficiency (Langlois-Bertrand <i>et al.</i> 2015:6). - Energy securities are not high on the municipal political agenda (Kruger and Tait, 2015:18). - High investment costs and the lack of incentives provided by the current regulatory framework present barriers to the exploitation of the available potential (DoE, 2016b:32) - Diverging actions between different agencies having partial authority over energy efficiency can be problematic (Langlois-Bertrand <i>et al.</i> 2015:7). - Insufficient institutional capacity - Agency's inadequate capacity to enforce mandatory measures and regulations (Langlois-Bertrand <i>et al.</i> 2015:7; Shen <i>et al.</i> 2012:17) - Regulation produces an incentive structure hindering energy efficiency measures (Langlois-Bertrand <i>et al.</i> 2015:7). - Lack of effective regulation and coordination between the public and the private sector resulting in the low priority of energy efficiency. (DoE, 2018:17). - Ineffective subsidy mechanisms and regulatory hurdles for provinces and municipalities to enter contracts with the private sector (SALGA, 2013:4) - Regulation is too slow to accommodate the fast-changing technologies (Bilous, 2020:15). - Lack of regulatory guides to enforce and monitor strategic outputs (DoE, 2018:14) - Lack of integrated planning results in ineffective regulations (DoE, 2018:16).

Theoretical barriers	Literature
	- When energy expenditures account for only a small share of electricity users' overall spending, there is a little financial incentive to reflect on energy efficiency (Schleich 2007:94) - Lack of institutional focus on promoting energy efficiency (Shen <i>et al.</i> 2012:19). - Procedures to enforce and prioritise EE requirements have not been put in place (DoE, 2018:17)
Governance barriers	
Standards	- Energy efficiency standards are generally lacking (South Africa, 1998:81; Winkler, 2006:84; Shen <i>et al.</i> 2012:17). - Insufficient reference guides and energy labels (Dunphy <i>et al.</i> 2018:6);
Institutional	- Lack of a well-defined implementation framework for the NDP (UNSD, 2019:20) - Principal-agent relationships arise due to a lack of trust between two parties at different levels within the organisation (Sorrell <i>et al.</i> 2004:10; Thollander <i>et al.</i>, 2010:50). - Limited capacity within key governance structures (DoE, 2018:17). - Limited coherence with relevant sectoral policies and legislation in terms of strategic implementation (DoE, 2018:17). - Low level of trust in ESCos (Aboltins and Blumberga, 2019:23). - Lack of leadership from top executives arises when the top managers and leaders do not commit themselves to the process of strategy implementation in an organisation (Lihalo, 2013:10). - Horizontal fragmentation - Failure to streamline government departments responsible for energy efficiency, e.g., DoE is the custodian of all energy policies and electricity security; DPE is responsible for the country's energy infrastructure, SANEDI is responsible for achieving the objectives of NEES, NERSA sets and approves the annual Eskom tariff increases (Greencape, 2015:11). - Inadequate coordination mechanisms: Government departments, agencies, and donors lack the coordination and unified approach required to create the policy certainty and dependable environment necessary for the buy-in and scale-up of EE behaviour and technologies on the part of the public and private sectors (Covary and Aversch, 2013:592). - Smaller municipalities lack planning capacity (UNSD, 2019:98) - Lack of alignment of national economic, industrial, energy, and climate objectives (Covary and Aversch, 2013:594). - Non-optimal enabling framework: Lack of effective mandate for government departments/branches or uncertainty as to mandate objectives (Covary and Aversch, 2013:594). - Need for capacity building: The upskilling of existing capacity and the recruitment of new resources in the public sector is vital if the government is to achieve its objectives (Covary and Aversch, 2013:594). - Energy manager lacks power and influence (Sorrell <i>et al.</i> 2004:5). - Impractical government targets - a gap between the policy targets set by governments and the actual results executed by the implementation (Seetharaman <i>et al.</i> 2019:8). - Lack of capacity at the local level and a lack of support structures at the national level (OECD/EIA, 2010:35). - Lack of coordination between the Department of Energy and the National Treasury (Covary and Aversch, 2013:594). - No comprehensive register of energy efficiency and renewable energy projects at the local level exists (SALGA, 2013:39). - A Large number of players within the sector and across spheres of government and a need to simplify and clarify institutions so that Municipalities have a clear line of access to support (SALGA, 2013:39). - During the transition from NEEP to NEEAP, no investigation into the barriers to energy efficiency in the South African landscape was carried out (Singh and Lalk, 2016:289). - Despite numerous advances in EE policy development and incentive programmes, the enactment of new EE policy measures has slowed down (DoE, 2018:1).

Theoretical barriers	Literature
	• Government leaders and key policymakers impede efforts to put on the agenda, elaborate, or successfully implement energy efficiency measures (Langlois-Bertrand <i>et al.</i> 2015:6). • High levels of corruption (Langlois-Bertrand <i>et al.</i> 2015:6; UNSD,2019:14). • Unavailability of energy efficiency standards (Thollander <i>et al.</i> 2010, 56). • Lack of political stability and effectiveness (Langlois-Bertrand <i>et al.</i> 2015:6) • Lack of political will to support energy efficiency (Kruger and Tait, 2015:19) • Bureaucratic and administrative hurdles (Seetharaman <i>et al.</i> 2019:7).

SECTION A:**Introduction to the project**

The aim of the interview questionnaire is twofold: Firstly, it seeks to identify and describe barriers to energy efficiency in specific South African municipalities. Secondly, it seeks to develop recommendations for policy and practice to overcome these barriers to reduce the energy efficiency gap and promote the development of green energy transitions in local government.

The purpose of this interview questionnaire is to collect and gather both qualitative and quantitative data on the barriers to energy efficiency in local government.

A. PARTICIPANT INFORMATION

Full Names	
Municipality	
Job Title	
Email	
Have you been involved in energy efficiency projects?	
Years working with energy efficiency projects	
Are you involved in making/advancing decisions on energy efficiency?	

A.1 CONSENT

I hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participate in the research project. I understand that I am at liberty to withdraw from participating at any given time, should I so desire.

Signature of Participant

Date

A.2 CONFIDENTIALITY

I assure you that your identity and that of your organisation will be treated confidentially. The information you provide will only be used for academic purposes and will not be shared with any other person.

Signature of Researcher

Date

SECTION B:

B. Awareness of the United Nations Sustainable Development Goals 2030 Agenda and the National Development Plan Vision 2030

- Are you aware of the following energy efficiency targets under the Sustainable Development Goals 2030 Agenda (Goal 7)?

- Target 7.1 - ensure access to affordable, reliable, and modern energy services.

YES

NO

- Target 7.2 - increase the share of renewable energy in the energy mix.

YES

NO

- Target 7.3 - Improvement in energy efficiency (electricity management and electricity technologies).

YES

NO

- If **Yes**, do you think the South African policy framework on energy efficiency can achieve these targets? Please provide reason(s).....

- Are you aware of the following energy efficiency targets under the South African National Development Plan Vision 2030?

- Municipalities are expected to reduce their electricity consumption by 50% on public buildings.

YES

NO

- Municipalities are expected to reduce their electricity consumption by 20% on municipal services.

YES

NO

- Municipalities are expected to reduce their electricity consumption by 30 % on municipal vehicle fleets.

YES

NO

- Do you think your municipality will be able to reach these targets by 2030? Please elaborate.....

- Please provide the energy efficiency targets of your municipality in the table below.

Variables	National Energy Efficiency Strategy		Municipal targets
	Goal	Accelerate the current rate of improvement in the electricity consumption per square meter in buildings	-

Public Building		occupied by the building sector at the national, provincial and municipal levels	
	<i>Target</i>	50% reduction in the specific electricity consumption by 2030	%
Municipal services	<i>Goal</i>	Accelerate the reduction in the specific electricity consumption per resident in In delivering municipal services	-
	<i>Target</i>	20% reduction in energy intensity of municipal service provisions, this includes street lighting, traffic lights, water supply, and wastewater treatment. 30% reduction in the fossil fuel intensity of municipality vehicle fleets	%

- Under the National Energy Efficiency Strategy, the South African economy is expected to reduce electricity consumption by 29% by 2030. Do you think this target is achievable?

Please provide the reason(s) for your choice.....

.....

- Do you think South Africa's 2030 energy efficiency policy targets are too ambitious to be achieved?

Please provide the reason(s) for your choice.....

.....

C. Understanding the role of energy efficiency in reducing high energy demand

- What is your general view on the status of energy efficiency in South Africa?.....
.....
- What are the drivers for energy efficiency in your municipality?
.....
- Do you think enough work has been done at the municipal level to stimulate the use of energy efficiency?.....
- Do you think energy efficiency practices have been used optimally to reduce the high energy demands in your municipality?.....
.....

E. Understanding energy efficiency practices in Municipalities

- Does your municipality have an energy efficiency policy?.....
- If **Yes**, does the policy have energy efficiency targets?.....
- Does your municipality have an energy manager?.....
- Please list several energy-efficient projects that your municipality has embarked on.
.....
.....
.....
.....
- Were the projects self-funded by your municipality or funded through the EEDSM programme?
.....
- What was the drive for these energy efficiency projects?.....
.....
- Has your municipality ever received funding from the Department of Energy?.....
- What have been the challenges in applying for funding from the Department of Energy?.....
.....
- Is your municipality capacitated to deal with energy efficiency management, e.g., energy audits?
.....
- Is the municipality equipped and able to identify barriers to energy efficiency?.....
.....
- If so, please share an effective approach to identifying electricity conservation opportunities.....
.....
- Has your municipality embarked on raising energy efficiency awareness amongst its staff and contractors?.....
- If so, please share how was this achieved?.....
.....

- How would you describe the relationship between your municipality and the provincial and national governments in addressing energy matters?.....

.....

- Has the uptake of energy efficiency in your municipality been effective in realizing electricity savings?

YES

NO

- If NO, please make recommendations to achieve more energy-efficient practices?.....

.....

SECTION C

F. Understanding the barriers to energy efficiency

Please rate the following barriers according to the scale provided below, where “1” = the barrier has an extremely low impact on energy efficiency initiatives; “2” = the barrier has little impact; “3” = the barrier has no impact; “4” = the barrier has a high impact and “5” = the barrier has an extremely high impact.

Rating scale	1	2	3	4	5
Interpretation	Extremely Low	Low	Moderate	High	Extremely High

TECHNICAL BARRIERS	Rating Score				
	1	2	3	4	5
	Extremely Low	Low	Moderate	High	Extremely High
Technological					
Lack of local energy efficiency technologies.					
Poor installation of energy efficiency technologies.					
Lack of maintenance of the newly installed energy efficiency technologies.					
Lack of technical capacity within the municipality to identify, appraise, develop, and implement energy efficiency projects.					
Contractors (ESCO) lack experience in project management					
Infrastructure					
Municipal infrastructure is too old for energy efficiency retrofit.					
Lack of infrastructure to accommodate energy efficiency technologies.					

- Please provide reasons for your highest-ranking.....

ECONOMIC BARRIERS	Rating Score				
	1	2	3	4	5

	Extremely low	Low	Moderate	High	Extremely High
Market failures					
Lack of information on the technical and technological parameters of energy efficiency products					
Lack of local suppliers (ESCOs).					
Suppliers (ESCOs) do not offer a diversity of energy efficiency technologies.					
Lack of good quality equipment, e.g., the light colour spectrum of LED fade over time.					
The demand for energy efficiency is too low.					
Financial barriers					
Energy efficiency technologies are often very expensive.					
Lack of internal funding for energy efficiency projects.					
Lack of finance to continue with energy efficiency projects.					
Lack of willingness to invest in energy efficiency.					
Behavioural economics					
Lack of awareness of the benefits of energy efficiency from the municipal staff					

- Please provide reasons for your highest-ranking.....

GOVERNANCE BARRIERS	Rating Score				
	1	2	3	4	5
	Extremely low	Low	Moderate	High	Extremely High
Policy failures					
Impractical government targets - a gap between the policy targets set by governments and the actual results executed by the municipalities					
Lack of energy efficiency policies at a municipal level.					
Lack of a well-defined energy efficiency implementation framework.					
Lack of clear electricity conservation targets.					
Regulatory					
Lack of regulatory framework and legislation for energy efficiency at a municipal level.					
Municipality's inadequate capacity to enforce mandatory measures and regulations.					
Lack of regulatory guides to enforce and monitor strategic outputs					
Standards					
Lack of energy efficiency standards and labels					
Lack of effective measurement and verification (M&V) protocol and implementation for					

documenting electricity savings in municipalities					
Organizational Failure					
Lack of leadership from top executives to enhance energy efficiency.					
Lack of metered or recorded electricity consumption and conservation.					
Energy manager lacks authority and influence					
Institutional					
Lack of political support to improve energy efficiency					
Political interference in electricity management programs					
High levels of corruption impede the financial support to energy efficiency projects					
Lack of coordination and cooperation between the stakeholders, i.e., the municipal, provincial, and national spheres					

- Please provide reasons for your highest-ranking.....
- Please identify any additional barrier that was not mentioned above.
.....
- What are the causes of the barriers identified in your list?
.....
- How can the municipality overcome these barriers?
.....

Annexure D: Likert Scale Rating

TECHNICAL BARRIERS	Rating Score						
	1	2	1 and 2	3	4	5	4 and 5
	Extremely Low	Low		Moderate	High	Extremely High	
Technological							
Lack of local energy efficiency technologies.	32%	27%	59%	14%	18%	9%	27%
Poor installation of energy efficiency technologies.	32%	23%	55%	27%	9%	9%	18%
Lack of maintenance of the newly installed energy efficiency technologies.	14%	36%	50%	18%	14%	18%	32%
Lack of technical capacity within the municipality to identify, appraise, develop, and implement energy efficiency projects.	14%	14%	28%	14%	27%	32%	59%
Contractors (ESCO) lack experience in project management	18%	23%	41%	36%	9%	14%	23%
Infrastructure							
Municipal infrastructure is too old for energy efficiency retrofit.	9%	27%	36%	23%	18%	23%	41%
Lack of infrastructure to accommodate energy efficiency technologies.	9%	41%	50%	27%	14%	9%	23%
ECONOMIC BARRIERS							
Market failures							
Lack of information on the technical and technological parameters of energy efficiency products	41%	23%	64%	18%	9%	9%	18%
Lack of local suppliers (ESCOs).	9%	45%	55%	18%	14%	14%	27%
Suppliers (ESCOs) do not offer a diversity of energy efficiency technologies.	18%	45%	64%	27%	5%	5%	9%
Lack of good quality equipment, e.g., the light colour spectrum of LED fade over time.	23%	41%	64%	9%	14%	14%	27%
The demand for energy efficiency is too low.	14%	27%	41%	36%	18%	5%	23%
Financial barriers							
Energy efficiency technologies are often very expensive.	5%	9%	14%	27%	36%	23%	59%

Lack of internal funding for energy efficiency projects.	5%	5%	10%	0%	45%	45%	90%
Lack of finance to continue with energy efficiency projects.	5%	9%	14%	9%	32%	45%	77%
Lack of willingness to invest in energy efficiency.	14%	5%	19%	23%	23%	36%	59%
Behavioural economics							
Lack of awareness of the benefits of energy efficiency from the municipal staff.	9%	18%	27%	27%	18%	28%	46%
GOVERNANCE BARRIERS							
Policy failures							
Impractical government targets - a gap between the policy targets set by governments and the actual results executed by the municipalities	9%	9%	18%	36%	27%	18%	45%
Lack of energy efficiency policies at a municipal level.	9%	14%	23%	14%	41%	23%	64%
Lack of a well-defined energy efficiency implementation framework.	9%	9%	18%	23%	36%	23%	59%
Lack of clear electricity conservation targets.	9%	9%	18%	23%	41%	18%	59%
Regulatory							
Lack of regulatory framework and legislation for energy efficiency at a municipal level.	14%	14%	27%	23%	36%	14%	50%
Municipality's inadequate capacity to enforce mandatory measures and regulations.	18%	23%	41%	27%	23%	9%	32%
Lack of regulatory guides to enforce and monitor strategic outputs	23%	23%	45%	18%	23%	14%	36%
Standards							
Lack of energy efficiency standards	18%	5%	23%	50%	18%	5%	23%
Lack of effective measurement and verification (M&V) protocol and implementation for documenting electricity savings in municipalities	14%	23%	36%	36%	18%	9%	27%
Organizational Failure							
Lack of leadership from top executives to	14%	14%	27%	32%	23%	18%	41%

enhance energy efficiency.							
Lack of metered or recorded electricity consumption and conservation.	9%	41%	50%	23%	18%	9%	27%
Energy manager lacks authority and influence	18%	18%	36%	18%	23%	23%	45%
Institutional							
Lack of political support to improve energy efficiency	23%	14%	36%	18%	36%	9%	45%
Political interference in electricity management programs	18%	18%	36%	36%	18%	9%	27%
High levels of corruption impede the financial support to energy efficiency projects	45%	18%	64%	14%	23%	0%	23%
Lack of coordination and cooperation between the stakeholders, i.e., the municipal, provincial, and national spheres	45%	23%	68%	14%	9%	9%	18%