



Evaluating the knowledge management framework of renewable energy in Gauteng, South Africa

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DECLARATION OF THE STUDY

I, P.S. Mashaba, hereby declare that the dissertation for the degree on Master of Business Administration at the North West University hereby submitted is an outcome of my independent and original work. The project has not previously been submitted by me for a degree elsewhere for publication or any other university. I have duly acknowledged all the sources from which the work, design, ideas, extracts and execution and all material contained herein have been taken or researched.

Signature:

A handwritten signature in black ink, appearing to be 'P.S. Mashaba', written over a horizontal line. The signature is stylized with many loops and is enclosed within a large, hand-drawn oval.

Date: 02/04/2024

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ABSTRACT

The study evaluated the knowledge management framework of renewable energy in Gauteng, South Africa. The knowledge management framework should encompass various aspects, including policy and regulatory frameworks, financing and investment models, technology innovation and diffusion, capacity building, stakeholder engagement, and monitoring and evaluation systems. Regardless, despite the growing interest in renewable energy as a solution for energy security and environmental sustainability in South Africa, significant gaps remain in understanding of the knowledge management framework for the renewable energy industry.

The study was conducted using a qualitative research approach where semi-structured interviews on a sample of 10 was used. The sample was reached using non-probability sampling executed using a purposive sampling technique. The elicited inferences were analysed using thematic analysis.

The findings highlight a vibrant ecosystem of collaboration and innovation, emphasizing knowledge sharing platforms, conferences, and interdisciplinary collaboration. Knowledge management proves crucial in advancing renewable energy technologies, facilitating expertise transfer, reducing errors, and supporting continuous improvement. The study identifies barriers, such as access to finance and regulatory uncertainties, and facilitators, including government support and policy frameworks. Clear policy, infrastructure expansion, and supportive frameworks are vital for addressing these challenges and promoting sustainable progress in South Africa's renewable energy sector. Additionally, the study underscores the importance of integrating knowledge management into policy and regulatory frameworks, proposing evidence-based recommendations for the success of renewable energy projects, including proactive collaboration, financial stability measures, streamlined grid connections, and advanced forecasting.

Keywords: renewable energy, knowledge management, South Africa, collaboration, policy frameworks, project success.

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ABBREVIATION AND ACRONYMS

CSS	Carbon Capture and Storage
DMRE	Department of Mineral Resources and Energy.
FiT	Feed-in Tariff
GDP	Gross Domestic Product
GIF	Green Innovation Fund
IPP	Independent Power Producer.
IRP	Integrated Energy Plan
KM	Knowledge Management
KPI	Key Performance Indicators
MKF	Management Knowledge Framework.
PAIA	Promotion of Access to Information Act.
POPIA	Protection of Personal Information Act.
R & D	Research and Development
REC	Renewable Energy Clusters
REFIT	Renewable Energy Feed-in Tariffs
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme.
REIPPP	Renewable Energy Independent Power Producer Procurement.
SA	South Africa
UNDP	United Nations Development Programme

1. CHAPTER ONE

1.1 INTRODUCTION:

The dynamic landscape of renewable energy in South Africa is not merely a response to the global need for sustainable power sources; it is a pivotal transformation in the nation's energy sector (Jacobson & Delucchi, 2011:2). As South Africa endeavours to diversify its energy mix and reduce its reliance on fossil fuels, renewable energy has emerged as a key player in this transition. Central to the success of this transformation is the effective management of knowledge related to renewable energy technologies, policies, and practices.

The knowledge management framework is a critical component in the development and implementation of renewable energy policies and projects (Odunlami & Van der Laan, 2018:2-6). It provides a strategic approach to renewable energy deployment and addresses the complex interplay of technical, economic, social, and environmental factors that affect the sector. In South Africa, the renewable energy sector has been growing steadily in recent years, driven by the country's abundant renewable energy resources and its commitment to reducing greenhouse gas emissions (International Energy Agency Report, 2020:8).

The knowledge management framework acts as a bridge, connecting researchers, policymakers, industries, and communities (Odunlami & Van der Laan, 2018:2-6). It facilitates the sharing of best practices, experiences, and innovations that collectively drive the growth of renewable energy. This framework also incorporates capacity building and the utilization of indigenous knowledge, ensuring that renewable energy projects align with the unique socio-cultural and economic contexts of South Africa. To understand the multifaceted aspects of knowledge management in renewable energy, this study dives into the strategies, challenges, and potential benefits. The exploration extends to the role of knowledge management in supporting policy and regulatory frameworks, technological innovation and diffusion, capacity building, and stakeholder engagement. Each component forms a crucial piece of the renewable energy puzzle, contributing to South Africa's sustainable energy future.

This study embarks on a journey to explore the knowledge management framework of renewable energy in South Africa, dissecting the intricate web of information, collaboration, and innovation that underpins this burgeoning sector (Department of Mineral Resources and Energy, 2023:16). As South Africa strives to harness its abundant solar, wind, and other renewable resources, the strategic management of knowledge becomes paramount. This knowledge encompasses a wide spectrum, from technical insights into cutting-edge energy technologies to insights into the intricate web of policy and regulatory frameworks (Eberhard *et al.*, 2019:144).

More so, the knowledge management is critical to renewable energy development in South Africa (Albino *et al.*, 2015:16). A comprehensive knowledge management framework should create a learning environment for renewable energy stakeholders that enhances their collective knowledge. The framework should facilitate the exchange of ideas and best practices among stakeholders to promote innovation in the renewable energy sector (Odunlami & Van der Laan, 2018:2-6). Moreover, the framework should be aligned with the country's unique challenges and opportunities and develop policies that are tailored to the country's political and institutional environment (Odunlami & Van der Laan, 2018:2-6).

In this age of environmental consciousness and the global pursuit of climate mitigation, South Africa stands at the precipice of an energy transformation (Eberhard *et al.*, 2019:144). This exploration of knowledge management in renewable energy within the South African context seeks to identify the challenges, strengths, opportunities, and gaps that will further fuel this transformation. By comprehensively understanding the knowledge landscape, this study endeavours to pave the way for evidence-based recommendations that can propel South Africa towards a more sustainable energy future.

1.2. BACKGROUND TO THE STUDY:

South Africa is a country with abundant renewable energy resources, including solar, wind, and biomass, which can contribute significantly to the country's energy mix and help to achieve its sustainable development goals (Department of Mineral Resources and Energy, 2021:19). The South African government has recognized the importance

of renewable energy in the country's energy transition and has implemented various policies and regulatory frameworks to support its development.

The Renewable Energy Independent Power Producer Procurement (REIPPP) program is one of the most significant policy initiatives aimed at attracting private investment in renewable energy projects in South Africa (Odunlami & Van der Laan, 2018:2-6). The program was launched in 2011 and has been successful in attracting significant private sector investment in renewable energy projects, with a total of 6,422 MW of renewable energy capacity procured as of May 2021 (Department of Mineral Resources and Energy, 2021:19). However, the integration of renewable energy into the national energy system poses several challenges that need to be addressed to ensure its sustainable deployment (Hughes & Grové, 2020:112).

One of the key challenges is the lack of a comprehensive knowledge management framework for renewable energy development in South Africa (Simões *et al*, 2018:1703-1713). Such a framework is essential to provide a strategic approach to renewable energy deployment and address the complex interplay of technical, economic, social, and environmental factors that affect the sector. The knowledge management framework should encompass various aspects, such as policy and regulatory frameworks, financing and investment models, technology innovation and diffusion, capacity building and skills development, stakeholder engagement and participation, and monitoring and evaluation systems (Odunlami & Van der Laan, 2018:2-6).

Existing research has highlighted the importance of a comprehensive knowledge management framework for renewable energy development in South Africa (Grobelaar & Van Niekerk, 2019:88; Hughes & Grové, 2020:112; Department of Energy Annual Report, 2021:18). For instance, Khan and Govender (2019:1156) argue that the development of a strategic management framework for renewable energy in South Africa is critical to ensure the successful implementation of renewable energy projects and the achievement of sustainable development goals. Similarly, Breytenbach *et al.* (2017:5-6) emphasize the need for a coordinated approach to renewable energy development in South Africa, which requires a comprehensive knowledge management framework that considers the various technical, economic, social, and environmental factors.

Despite the importance of a knowledge management framework for renewable energy development in South Africa, there is a lack of research on its development and implementation. Existing studies are limited in scope and depth and focus mainly on specific aspects of renewable energy development, such as policy and regulatory frameworks (Hughes & Grové, 2020:112; Mbatha *et al.*, 2019). Therefore, there was a need for further research that can provide a comprehensive understanding of the management knowledge framework for renewable energy in South Africa and identify gaps and opportunities for its development and implementation.

1.3. PROBLEM STATEMENT

South Africa is currently facing significant challenges in meeting its energy demands, which is largely dependent on fossil fuels. This dependence on fossil fuels has led to significant environmental degradation, including air and water pollution, and increased greenhouse gas emissions. However, in line with the global effort to mitigate greenhouse gas emissions and further climate harm, South Africa has set ambitious targets for renewable energy deployment to reduce its dependence on fossil fuels and mitigate the impacts of climate change (Hughes & Grové, 2020:112). This includes the Renewable Energy Independent Power Producer Procurement Program (REIPPPP), which aims to add significant renewable energy capacity to the grid.

However, the integration of renewable energy into the national energy system poses several challenges due to intermittency issues and grid constraints. Department of Energy Annual Report (2021:18) propounded that there have been periods of policy uncertainty and delays in government decision-making, which can deter investment and slow the growth of the renewable energy sector. In this perspective, Hughes and Grové (2020:114) accredited the challenge to a lack of a comprehensive knowledge management framework for renewable energy development in the country. As noted in developed countries, knowledge management framework is essential to provide a strategic approach to renewable energy deployment and address the complex interplay of technical, economic, social, and environmental factors that affect the sector (Hughes & Grové, 2020:112). The knowledge management framework should encompass various aspects, including policy and regulatory frameworks, financing and investment models, technology innovation and diffusion, capacity building, stakeholder engagement, and monitoring and evaluation systems (Mbatha *et al.*, 2019). However,

given South Africa's state as an emerging economy, there is a paucity of research on the development and implementation of such a framework, with existing studies characterized by limited scope, context specificity and depth.

Regardless, despite the growing interest in renewable energy as a solution for energy security and environmental sustainability in South Africa, significant gaps remain in understanding of the knowledge management framework for the renewable energy industry. This study aims to investigate and address this knowledge gap by examining the current status of knowledge management practices, identifying challenges and opportunities, and providing evidence-based recommendations to enhance knowledge sharing and innovation in the renewable energy sector in South Africa as an emerging economy.

1.4. RESEARCH OBJECTIVES

1.4.1. Primary objective:

The purpose of this research is to explore the knowledge management framework of renewable energy in Gauteng and identify challenges, strengths, opportunities, and gaps for further research. This is achieved through addressing the secondary objectives below:

1.4.2. Secondary objectives:

The primary objective, which comprises the following, was supported by the organized secondary objectives, which are as follows:

- Investigate the existing knowledge management strategies and best practices employed in the South African renewable energy sector.
- Analyse the key barriers and facilitators that impact the effectiveness of knowledge management in the context of renewable energy in South Africa;
- Investigate the current state of renewable energy in South Africa and how can the knowledge management framework be effectively integrated into policy and regulatory frameworks to support renewable energy deployment.

- Formulate evidence-based recommendations for the development and integration of an improved knowledge management framework within the renewable energy in South Africa.

1.5. SCOPE OF THE STUDY

1.5.1. Field of study:

The field of study for is likely to fall within the interdisciplinary field of renewable energy management. This field combines knowledge from various disciplines such as engineering and business management.

Overall, the study aims to provide insights into the key management knowledge and strategies required for successful renewable energy development and implementation in Gauteng, as well as identify opportunities for further research and development in this area.

1.5.2 Sector/industry/Areas to be investigated.

This study was performed in the Solar power generation in renewable energy sector. The areas to be explored were renewable energy sector specific the management personnel to broadly evaluate management knowledge framework of renewable energy.

1.5.2. Geographical demarcation:

This study was performed in Gauteng on Solar power generation industry which are already in renewable energy business.

1.6 EMPIRICAL STUDY

The section summarises the empirical study where the research paradigm, research approach, research strategies and techniques are introduced.

1.6.1 Research paradigm

The adoption of a research paradigm involves a structured approach to investigate, analyse, and enhance the knowledge management practices within the South African

renewable energy sector. The paradigm emphasizes context-specific understanding and aims to bridge knowledge gaps, ultimately contributing to the sustainable development of renewable energy in the country (Saunders, Lewis & Thornhill, 2019:92). Given the inductive nature of the study and South Africa's renewable energy landscape which is influenced by a multitude of social, economic, and environmental factors, an interpretivism paradigm was adopted. An interpretive approach allows researchers to explore these complex contexts, providing a nuanced understanding of how knowledge management operates within this unique environment (Creswell, 2021:295).

1.6.2 Research approach

Given the novelty of knowledge management framework in the renewable energy fraternity within South Africa, the study adopts an inductive approach. The inductive research approach is a qualitative research method that involves collecting and analysing data without a predetermined hypothesis or theory (Creswell, 2021:72). This approach is often used in exploratory research where the goal is to understand a phenomenon, identify patterns, and generate new insights. The inductive approach is particularly suitable for theory generation (Kumar, 2020). In this study, it can be used to develop new theories or refine existing ones related to knowledge management in the context of renewable energy in South Africa. Thus, the researchers can derive insights and patterns from the data, leading to the formulation of conceptual frameworks and theories specific to the South African context.

1.6.3 Methodological choice

In line with an interpretivism paradigm and inductive research approach, the study employs a qualitative research approach. Qualitative research is adept at delving into complex phenomena. In the context of renewable energy, issues like policy implementation, stakeholder interactions, and local community engagement are multifaceted (Flick, 2022:571). This approach is highly applicable for this study as it allows for in-depth exploration and interpretation of the complex factors influencing renewable energy and knowledge management in the South African context. Also, qualitative research can contribute to theory development by identifying patterns and themes in the data. In this study, it can lead to the development of a comprehensive

knowledge management framework tailored to South Africa's renewable energy sector.

1.6.4 Research strategy

A research strategy is a plan developed by the researcher to answer the research question or to accomplish the study objectives (Saunders et al., 2019:189). However, given the nature of the research problem, an interpretivist research strategy is highly applicable to explore the knowledge management framework of renewable energy in South Africa. Among the interpretivist research strategy techniques such as focus groups, interviews and case studies, interviews are well-suited for understanding the complex and context-specific aspects of knowledge management in the renewable energy sector (Creswell, 2021:562). Qualitative interviews allow for a deep exploration of their experiences, perspectives, challenges, and insights related to knowledge management in the sector. Through open-ended questions, the study can gain a comprehensive understanding of their knowledge management practices, the barriers they face, and the strategies they employ.

1.6.5 Time horizon

The research time horizon establishes the duration of the study, which may be cross-sectional or longitudinal in nature. In this study, a cross-sectional study time horizon is well-suited for exploring the knowledge management framework of renewable energy in South Africa, as it allows for a snapshot of the current state of knowledge management practices, challenges, and opportunities in the sector. Cross-sectional studies are often more efficient and timely compared to longitudinal studies, making them suitable for capturing the "here and now" of knowledge management practices in a rapidly evolving field like renewable energy (Kumar, 2020:98). The findings from a cross-sectional study can have immediate policy relevance.

1.6.6 Population and Sampling Framework

The study population was focused on management personnel within sectors of the industry involved in the management of solar power generation in Gauteng, South Africa. This included state organisations which is responsible for a significant portion of the country's power generation, as well as independent power producers (IPPs) that

operate in the renewable energy sector. The study may also involve experts and stakeholders in the energy sector who have experience with the management of renewable energy projects, including researchers, engineers, project managers, and industry leaders.

The sample was determined through a non-probability sampling executed through a purposive or judgemental sampling technique. The key characteristics of inclusion criteria are those of the population included relevant expertise, management position, project involvement, experience above 5 years and diversity as well as availability. The exclusion criteria were non-management positions, experience less than 5 years and lack of involvement in renewable energy. The contact details were collected from the public platforms. A sample of 10 participants was used given Creswell (2021:84)'s deliberation that for a qualitative study a sample of 8-20 is sufficient for data saturation.

1.6.7 Data Collection Methods

Data collection methods are the techniques and processes used to gather information and data for research or study purposes (Flick, 2022:176). The choice of data collection methods depends on the research objectives, the nature of the data, the available resources, and ethical considerations. In line with the qualitative research approach, data was collected using semi-structured interviews. Semi-structured interviews are well-suited for in-depth exploration of complex topics. They allow the researcher to delve deeply into the subject matter, providing a comprehensive understanding of the knowledge management framework in the renewable energy sector in South Africa (Saunders et al., 2023:176). Therefore, the approach is highly applicable for this research, as they offer a flexible, context-sensitive, and participant-centred approach to data collection.

1.6.8 Data Analysis

In order to understand the findings, the study employed thematic analysis techniques. Thematic analysis can systematically organize large amounts of qualitative data, including data from semi-structured interviews (Flick, 2022:176). Data can be transcribed, coded, and categorized into themes for further analysis. Thematic analysis is great for identifying patterns, trends, and recurring ideas in your data. In the context

of this study, it helps to identify recurring themes related to knowledge management in the South African renewable energy industry. Thematic analysis provides a rigorous and structured approach to derive meaningful insights from the data collected, ultimately helping to achieve the research objectives and enhance knowledge management in the renewable energy sector (Kumar, 2020:45).

1.6.9 Trustworthiness of the Study

Ensuring trustworthiness in qualitative research is critical to establishing the trustworthiness and reliability of the findings. By undertaking a number of activities, the research will meet the pillars of credibility; trustworthiness, transferability, reliability, and consistency (Flick, 2022:177). By integrating these strategies, the study can enhance its credibility and ensure that the findings are robust, reliable, and trustworthy. This is particularly important in qualitative research, as the interpretation of data may be affected by a variety of factors.

1.6.10 Ethical Considerations

Research ethics are the principles, guidelines, and standards that govern the conduct of research involving human subjects, animals, or other sensitive areas. Ethical considerations are essential to ensure the rights, safety and well-being of participants, the integrity of the research process, and the trustworthiness of research results. In this study, the researcher ensured informed consent, ensure that participants were not harmed, ensure anonymity and confidentiality, ensure voluntary participation, and ensure that permission is obtained from various gatekeepers before commencing the empirical study. The ethical clearance was approved and the ethical clearance number is: [N W U – 0 1 8 8 0 – 2 3 – A 4].

1.7 LIMITATIONS OF THE STUDY

While the study makes important contributions to the field of renewable energy management in South Africa, there were also some limitations that should be considered. The study's main focus is only on the management knowledge framework of renewable energy in the South African environment. Other factors that may influence the successful implementation and management of renewable energy projects, such as social and environmental factors, were not considered. The study relied solely on

qualitative data, which may limit the ability to make precise and accurate conclusions about the management knowledge framework of renewable energy in South Africa.

1.8 CHAPTER ORGANISATION:

The study is structured into four chapters:

1.8.1. Chapter One: Introduction:

Chapter one serves as an introduction to the study where the background of the study, research problem, and research objectives were outlined. The chapter provides a foundation on where the broader study is premised on.

1.8.2. Chapter Two: Literature Review:

Chapter two reviews the prevailing bodies of literature to gain a broader understanding of the subject under study.

1.8.3. Chapter Three: Research Design and Methodology:

Chapter three deliberates the research design and the research methodology which the study employed in the primary study. It also discusses, interprets, analyses, and presents the research findings gained from the research.

1.8.4. Chapter four: Conclusions and Recommendations:

Chapter four summarises the conclusions and recommendations of the study. The conclusions were drawn from the findings in both the literature review and the primary study.

1.9 Chapter Summary

This chapter sets the scene by providing an overview of the study where the parameters of the study were outlined. The background of the study, research problem, research objectives, research questions, the aim of the study, the significance of the study, and chapter organisation were all outlined in the study. The thrust is to create a foundation where the study can be built on; in examining the significance of strategic management towards the sustainability of the energy mix in South Africa.

This chapter delves into the crucial aspect of knowledge management in the context of renewable energy in South Africa. The dynamic landscape of renewable energy in the country presents both challenges and opportunities as it seeks to transition to more sustainable and eco-friendly energy sources. The lack of a comprehensive knowledge management framework has been identified as a significant barrier to the successful deployment of renewable energy.

The chapter outlined the research objectives, framed within an interpretivism paradigm and an inductive research approach, aimed to investigate existing knowledge management strategies, analyze barriers and facilitators, and provide evidence-based recommendations for an improved knowledge management framework. By conducting qualitative interviews with relevant experts and stakeholders in the renewable energy sector, the study sought to gain insights into the complex factors that influence knowledge management in this specific context.

The chapter also introduced the limitations of the study and the chapter organisation of the entire study. The next chapter is the literature review where prevailing bodies of authorities are interrogated to gain a deeper understanding of the subject under discussion.

CHAPTER TWO: LITERATURE REVIEW:

2.1 INTRODUCTION

The previous chapter sets an overview of the study where parameters were drawn by providing the research background, research problem, and research objectives. The chapter sets the foundation on where the study can be premised and an empirical overview of the examination of knowledge management framework of renewable energy in South Africa. This chapter is abbreviated comprehensive review of literature regarding knowledge management and renewable energy interplay. Creswell (2018:70) propounded the literature review as a comprehensive summary of previous research on a particular subject.

The review builds on the interrogation of previously published books, articles, and applicable sources by several think tanks and authorities for the sole thrust of gaining a broader perception of the subject under study. The same chapter assists with describing, summarising, and enumerating of the knowledge management framework for renewable energy in south Africa as major concepts. The same review unpacks the management challenges, opportunities, gaps and skill and capability management with renewable energy sector in south Africa. The chapter commences by defining the major constructs of the study and then addresses the objectives by drawing views and perceptions from previous writers on the management discourse.

2.1.1 South African renewable energy resources

South Africa has significant renewable energy potential, including wind, solar, hydropower, and biomass (Joemat-Pettersson, 2015:46-53). However, according to the Department of mineral resources and energy (2023:61), the country's energy mix is still dominated by fossil fuels, which has resulted in greenhouse gas emissions and energy insecurity. Renewable energy development requires a knowledge management framework to address the challenges of integrating renewable energy sources into the country's energy system. This literature review aims to identify the current state of knowledge management in the renewable energy sector in South Africa.

2.2 DEFINING MAJOR CONSTRUCT:

The major constructs of the study are knowledge management, clean and renewable energy. The discussion of these constructs is drawn from literature across the globe and the concepts will be traced to their historical development.

2.2.1. Conceptualisation of Knowledge management

Knowledge management involves a systematic process that encompasses the generation, acquisition, structuring, retention, retrieval, and dissemination of information and expertise within an organization (Girard & Girard, 2015:31). The objective is to enhance organizational efficiency and competitive advantage by addressing both implicit (personal) and explicit (formally documented) knowledge. This practice involves a spectrum of strategies, methodologies, and technologies that support knowledge-related operations (Omotayo, 2015: 22). Additionally, Dalkir (2017:45) emphasizes that the purpose of knowledge management is to improve decision-making, overall performance, and foster innovation within the organization. Therefore, knowledge management incorporates various strategies and techniques aimed at effectively managing and leveraging an organization's knowledge assets, encompassing both tacit (personal) and explicit (codified) knowledge. The implementation of these practices is crucial for enhancing organizational effectiveness and sustaining a competitive advantage (Omotayo, 2015:22).

According to Dalkir (2017:45), the effective implementation of knowledge management often requires a framework. A knowledge management framework is a structured approach or system employed by organizations to identify, capture, store, manage, and distribute knowledge and information internally (Girard & Girard, 2015:31). It encompasses the technology used for facilitating knowledge sharing, the leadership supporting it, and the processes developed to manage knowledge assets (Omotayo, 2015: 22). In this context, Dalkir (2017:45) asserts that the framework's goal is to facilitate the creation, sharing, and application of knowledge, thereby improving decision-making, problem-solving, innovation, and overall organizational performance. Essentially, a knowledge management framework provides a structured foundation for managing, creating, and disseminating various forms of organizational knowledge.

Furthermore, knowledge management framework differs and are normally context specific. However, the framework can be graphically illustrated as per below:



Figure 2.1: Knowledge Management Framework

Source: Dalkir, (2017:45)

As illustrated above, knowledge management framework often encompasses people, business process, content, and technology. The complexity of a knowledge management framework can vary depending on the size and needs of the organization (Girard & Girard, 2015:31). In this regard, the frameworks are particularly valuable in knowledge-intensive industries such as research, development, consulting, and technology, where leveraging existing knowledge can lead to significant competitive advantages.

2.2.2. Renewable energy:

Growing awareness of the environmental impact of fossil fuels, including air pollution, water pollution and greenhouse gas emissions, has led to an increased focus on clean energy alternatives (Mohtasham, 2015:16). Awareness of climate change and its associated risks has led governments, organizations, and individuals to seek low-carbon and sustainable energy sources such as wind, solar and hydropower.

Government policies and incentives such as tax credits, feed-in tariffs, and renewable energy standards encourage the development and adoption of renewable energy technologies (Peake, 2018:20). Among other things, these precedents have played a crucial role in the growth of renewable energy as a viable and sustainable source of electricity globally. Renewable energy refers to energy that is derived from natural resources that are replenished over time, such as solar, wind, hydro, geothermal, and biomass (Harjanne & Korhonen, 2019:7). Unlike non-renewable energy sources, such as fossil fuels, which are finite and can be depleted, renewable energy sources are virtually inexhaustible and can provide a sustainable and environmentally-friendly alternative to traditional energy sources. Renewable energy is seen as a key component of the global energy transition towards a low-carbon economy and is expected to play an increasingly important role in meeting the world's growing energy demand (International Renewable Energy Agency Report on Energy Efficiency, 2021:27).

2.2.3. Clean energy

Clean energy is a term used to describe energy sources and technologies that produce little to no greenhouse gas emissions and other pollutants and have a minimal impact on the environment (United Nations Development Programme (UNDP), 2016:36). These sources include renewable energy sources such as solar, wind, hydro, geothermal, and biomass, as well as other low-emission sources such as nuclear power and natural gas with carbon capture and storage (CCS) technology (International Energy Agency Report on Energy Security (204), 2020:18).

Green energy is considered an important tool in mitigating climate change and reducing global greenhouse gas emissions (Harjanne & Korhonen, 2019:8). By transiting to clean energy sources, countries can reduce their dependence on fossil fuels, which are responsible for a significant proportion of global greenhouse gas emissions. Additionally, the growth of the clean energy sector has the potential to create jobs and drive economic growth, particularly in developing countries (United Nations Development Programme, 2016:36).

Clean energy, also known as renewable energy or green energy, refers to energy generated from sustainable and environmentally friendly sources that have minimal or

no adverse impact on the environment and human health (International Renewable Energy Agency Report on Energy Efficiency (169), 2021: 28). These energy sources are typically characterized by their low or zero emissions of greenhouse gases and pollutants during electricity generation or heat production. Clean energy technologies harness natural resources such as sunlight, wind, water, geothermal heat, and biomass to produce electricity, heat, and fuel for various applications (Jacobsson & Bergek, 2011:400).

2.2.2.1 Differentiate between renewable and clean energy

Renewable energy and clean energy are related but distinct concepts. While both types of energy are associated with lower carbon emissions and reduced environmental impact, there are some key differences between them (Harjanne & Korhonen, 2019:9).

Clean energy, on the other hand, refers to energy sources and technologies that produce little to no greenhouse gas emissions and other pollutants and have minimal impact on the environment (Twidell, 2021:50). This includes renewable energy sources such as wind, solar, and hydro, but also other low-emission sources such as nuclear power and natural gas with carbon capture and storage (CCS) technology (International Energy Agency, 2020:14).

Renewable energy refers to energy sources that are naturally replenished and can be used indefinitely, while clean energy refers to energy sources and technologies that produce little to no greenhouse gas emissions (Twidell, 2021:51). In this regard, the environmental impact of renewable energy and clean energy are terms often used interchangeably, and examples of both can be found in various sources.

2.2.4 Key Elements in the Renewable Energy Landscape

In promising a sustainable and environmentally friendly future, the renewable energy sector is a rapidly evolving field with various key elements and initiatives (Mohtasham, 2015:1289). These elements play a crucial role in driving the adoption and integration of renewable energy into the global energy matrix. In this discussion, schemes such as Independent Power Producers (IPP), Feed-in Tariff (FiT), Renewable Energy Clusters (REC), Renewable Energy Feed-in Tariffs (REFIT) Program, Integrated

Energy Plan (IRP) and Green Innovation Fund (GIF) are summarised. By examining the importance, contributions and challenges associated with these elements, the goal is to gain a comprehensive understanding of the renewable energy sector and its impact on sustainable development.

2.2.4.1 IPPs (Independent Power Producers):

Independent Power Producers (IPPs) are private companies or entities that generate electricity or energy independently from government-owned utilities or state-owned enterprises. IPPs typically operate power generation facilities such as solar farms, wind turbines, or biomass plants. They play a significant role in expanding renewable energy capacity by developing and operating clean energy projects in collaboration with government initiatives or through private investments (Ministry of Energy, South Africa, 2020:42).

2.2.4.2. Renewable Energy Clusters:

Renewable energy clusters are geographical areas or regions where multiple renewable energy projects and related industries are concentrated. These clusters foster collaboration, knowledge sharing, and resource optimization among various stakeholders in the renewable energy sector, such as project developers, researchers, government agencies, and supporting businesses. The clustering of renewable energy activities can lead to economies of scale, increased innovation, and improved infrastructure, ultimately accelerating the growth of the clean energy sector (White, 2016:62).

2.2.4.3. Feed-in Tariffs (FiTs):

Feed-in tariffs (FiTs) are government policies or mechanisms that supply incentives to renewable energy producers by guaranteeing them a fixed payment for the electricity they generate and feed into the grid. FiTs are designed to promote renewable energy adoption by making it financially attractive for individuals, businesses, or independent power producers to invest in clean energy projects. These tariffs often aim to stimulate the development of renewable energy capacity and reduce reliance on fossil fuels (National Energy Regulator of South Africa, 2021:53).

2.2.4.4. Renewable Energy Feed-in Tariffs (REFIT) Program:

South Africa's Renewable Energy Independent Power Producer Procurement (REIPPP) program, including the REFIT framework, encourages knowledge exchange among stakeholders. The program's guidelines (Department of Energy, 2011;8) outline transparent criteria for project selection, technical specifications, and reporting, fostering the dissemination of best practices and lessons learned across the renewable energy industry. Empirical studies affirmed that South Africa's electricity grid has faced integration challenges as it incorporates a growing share of renewable energy (National Energy Regulator of South Africa, 2021:53). Critics point out that the alignment of the REIPPP program with grid integration has been a source of contention (Twidell, 2021:67-71). Ensuring that the grid can handle intermittent renewable energy sources effectively is crucial for program success.

2.2.4.5. Integrated Energy Resource Plan (IRP):

The South African government's IRP (Department of Mineral Resources and Energy, 2019:38) outlines the country's energy mix and future targets. By mandating regular updates and consultations, the IRP promotes continuous learning and adaptation, allowing knowledge to inform energy policy decisions and technological advancements. However, some literature suggests that IRPs may lack clarity in some areas, making it difficult for stakeholders to understand the government's exact priorities and plans. Twidell (2021:67-71) further propounded that as South Africa integrates more renewable energy into its grid, the IRP should focus more on grid infrastructure and integration challenges.

2.2.4.9 Knowledge Platforms and Stakeholder Engagement

South Africa promotes knowledge sharing and collaboration through various platforms, including renewable energy conferences, seminars, and online forums (Department of Science and Innovation, 2020:29). These mechanisms enable stakeholders to exchange information on regulatory frameworks, market trends, and technological advancements, fostering a culture of knowledge dissemination and innovation.

2.3 KNOWLEDGE MANAGEMENT OF RENEWABLE ENERGY

In an era of urgent need for sustainable energy solutions and the global transition to renewable resources, knowledge management has become a key pillar of progress in the renewable energy sector (Abbas & Sağsan, 2019:611). The management of knowledge, information and expertise has the power to drive innovation, facilitate efficient energy production and shape the future of clean and sustainable power generation (Ernst & Young, 2021:13).

2.3.1. Knowledge management of renewable energy in General:

In recent years, renewable energy has emerged as a focal point in addressing climate change and establishing a sustainable energy infrastructure. To effectively oversee and execute renewable energy projects, a profound grasp of the technology, policies, and market dynamics is paramount. Albino *et al.*, (2015:16) introduced a system dynamics approach to managing knowledge in renewable energy, emphasizing the integration of diverse knowledge sources, including scientific research, sector insights, and governmental regulations. Similarly, Simões *et al.*, (2018:1703-1713) underscored the pivotal role of knowledge management in driving innovation and enhancing competitiveness within the renewable energy sector. They contended that efficient knowledge management practices, such as sharing insights, fostering collaboration, and fostering continuous learning, empower organizations to optimize their performance and adapt to the evolving market landscape.

Furthermore, Simões *et al.*, (2018:1703-1713) delved into the significance of education and training in cultivating a skilled workforce for the renewable energy domain. They advocated for a multidisciplinary approach that amalgamates engineering, economics, policy, and environmental sciences to provide students with a holistic understanding of both the technical and societal facets of renewable energy. These studies collectively highlight the indispensable role of managing knowledge in facilitating the adoption and implementation of renewable energy technologies (Twidell, 2021:67-71). They also call for expanded research endeavours and enhanced collaboration among stakeholders to address the sector's challenges and seize its opportunities.

2.3.2. Knowledge Management Practices in Renewable Energy:

Knowledge management is the linchpin of progress in South Africa's renewable energy industry, underpinning innovation, collaboration, and the effective utilization of sustainable energy technologies (Abbas & Sağsan, 2019:611). In this dynamic sector, diverse strategies and approaches are harnessed to manage knowledge, driving the development and deployment of renewable energy solutions. Thus, within the South African context, knowledge management is frequently manifested through collaborative research and development endeavours, forging partnerships among universities, research institutions, and private sector entities (Ernst & Young, 2021:17). These collaborations are designed to harness collective expertise, share insights, and collectively pioneer innovative technologies and solutions (Smith *et al.*, 2020:41).

Furthermore, the industry's emphasis on knowledge transfer is instrumental in introducing international expertise to local practitioners, enabling the exchange of best practices, technical proficiency, and operational knowledge (Abbas & Sağsan, 2019:613). Capacity-building workshops, training programs, and technology transfer agreements are pivotal in fostering knowledge diffusion and skill enhancement (Jones & White, 2018:35). Notably, the sector extends its knowledge management efforts to engage with local communities and embrace their indigenous wisdom and traditional practices. This involves understanding communities' energy requirements, integrating their insights into project planning, and aligning renewable energy initiatives with cultural values and socioeconomic contexts (Munshi *et al.*, 2017:83).

Furthermore, knowledge management transcends sector boundaries, encompassing cross-sector collaborations with industries like agriculture, water management, and urban planning. These collaborations harness shared knowledge to craft integrated solutions that tackle interconnected challenges and foster sustainable development (Smith & Brown, 2021:93). Through collaborative efforts among stakeholders spanning government, the private sector, and local communities, challenges are surmountable, and shared goals are attainable (Mabugana & Nhamo, 2020:5).

By and large, the renewable energy sector in South Africa thrives on the foundation of effective knowledge management, as it empowers stakeholders to shape a more sustainable energy future, maximize efficiency, and address the multifaceted challenges on the path to cleaner and more accessible energy solutions. Through

shared knowledge, innovation, and collaboration, South Africa is poised to build a brighter and more sustainable energy landscape for all.

2.3.3. Importance of Knowledge Management for Sustainable Development:

Knowledge management ensures that decision-makers have access to accurate and up-to-date information, enabling them to make informed choices that align with sustainable development objectives (Pfeffer & Sutton, 2006:56). By sharing knowledge about resource utilization and conservation strategies, organizations can optimize resource allocation to minimize environmental impact and maximize efficiency (Abbas & Sağsan, 2019:614). Therefore, effective knowledge management fosters innovation by encouraging the exchange of ideas, lessons learned, and technological advancements, leading to the development of more sustainable solutions.

2.3.4. Importance of Knowledge Management for Renewable Energy Adoption:

By sharing knowledge about renewable energy systems and practices, knowledge management supports capacity-building efforts among stakeholders, enabling them to effectively operate, maintain, and innovate in the renewable energy sector (Abbas & Sağsan, 2019:616). Knowledge management is a pillar of the transition to renewable energy and plays a key role in unlocking its potential and overcoming various challenges. In general, knowledge management in the context of renewable energy adoption can help promote innovation, enable effective decision-making, enhance the economic viability of projects, and ensure the sustainability of the sector (Ernst & Young, 2021:21). Therefore, it provides stakeholders with the tools and information they need to drive the transition to cleaner, more sustainable energy.

2.4 CURRENT STATE OF RENEWABLE ENERGY SECTOR IN SA

South Africa has made significant strides in renewable energy development in recent years. The country's Renewable Energy Independent Power Producer Procurement (REIPPP) program, launched in 2011, has been instrumental in attracting private investments and fostering renewable energy growth (Eberhard *et al.*, 2016:28). This program has contributed to the diversification of the energy mix and reduced dependence on fossil fuels.

The renewable energy sector in South Africa has been growing steadily over the past decade, with significant investments in renewable energy projects and policies to support the transition towards a cleaner energy future (Ernst & Young, 2021:27). According to the South African Department of Mineral Resources and Energy (DMRE), renewable energy contributed 10.6% to the country's electricity generation in 2020, up from 6.7% in 2016 (DMRE, 2021:17). The country has set a target of 18.3 GW of renewable energy capacity by 2030, with a focus on wind and solar power (DMRE, 2021:17).

The Government has implemented various policies to support the development of renewable energy projects, including the Renewable Energy Independent Power Producer Procurement Program (REIPPPP). This program has attracted significant investments from local and international companies, with a total of 112 renewable energy projects awarded contracts under the program as of June 2021 (REIPPPP, 2021:21).

In addition, the government has established various incentives and tax breaks for companies investing in renewable energy projects, including accelerated depreciation for renewable energy assets and a carbon tax offset allowance (Ernst & Young, 2021:7). Despite the progress made, there are still challenges facing the renewable energy sector in South Africa, including regulatory barriers, limited transmission capacity, and intermittent energy supply from renewable sources (Ernst & Young, 2021:4). However, the government has committed to addressing these challenges and supporting the growth of the renewable energy sector.

2.4.1. The Renewable Energy Independent Power Producer Procurement (REIPPPP) Program:

The REIPPPP program is a flagship initiative in South Africa's renewable energy landscape. It has successfully attracted private investments and independent power producers (IPPs) into the renewable energy sector (Eberhard *et al.*, 2016:28). The program has been instrumental in the procurement of renewable energy projects, including wind, solar, and biomass. However, some criticism has been directed at the REIPPPP scheme regarding grid integration (Ernst & Young, 2021:14). As the plan integrates increasingly renewable energy into the national grid, challenges related to

the intermittency of renewable energy have emerged (REIPPPP, 2021:31). Thus, ensuring the grid's ability to effectively manage these fluctuations has been a source of debate and a point of contention.

2.4.2. Solar Energy Development:

South Africa has abundant solar resources, and solar energy plays a crucial role in the country's renewable energy portfolio. The government's commitment to solar energy is evident in the establishment of solar parks and large-scale solar projects (Nkambule & Smith, 2020:42). The Integrated Resource Plan (IRP) includes targets for the deployment of solar energy capacity (Nkambule & Smith, 2020:42). However, in South Africa this initiative is impeded by regulatory issues. Some critics have highlighted the regulatory challenges associated with solar development (Ernst & Young, 2021:18). They argue that bureaucratic red tape and complex permitting processes could hinder the timely implementation of solar projects. Therefore, while South Africa's commitment to solar development is clear, critics have raised legitimate concerns about grid integration challenges, resource variability, environmental impacts, economic viability, regulatory barriers and social equity.

2.4.3. Challenges and Future Prospects:

Despite progress, challenges remain in South Africa's renewable energy sector. These challenges include grid integration, policy stability, and financing constraints (Govender *et al.*, 2019:128). However, the country's commitment to renewable energy development and the success of the REIPPPP program indicate a promising future for the sector (Govender *et al.*, 2019:128).

South Africa has made considerable progress in renewable energy development, driven by policies and initiatives such as the REIPPPP program (Govender *et al.*, 2019:129). The country's commitment to solar and wind energy, along with the Integrated Resource Plan (IRP), provides a framework for continued growth in the renewable energy sector. However, challenges such as grid integration and financing constraints need to be addressed to ensure the sector's long-term sustainability and success. However, to ensure the continued success and sustainability of the renewable energy sector in South Africa, it is imperative to take proactive measures

that address these challenges. The state may consider improving the integration of renewable energy sources into the national grid, maintaining policy stability is crucial to attract investments and ensure the long-term success of renewable energy projects, explore avenues for affordable financing options for renewable energy projects and embracing technological advancements (Department of Science and Innovation, 2020:30).

2.4.4 Policies and Institutions Governing Renewable Energy in South Africa

Policies and institutions governing renewable energy in South Africa play a pivotal role in shaping the nation's transition to clean and sustainable energy sources (Govender *et al.*, 2019:130). These policies and institutions form the regulatory framework, which guides the development, deployment, and management of renewable energy technologies. South Africa has made significant strides in this regard, driven by its commitment to reducing greenhouse gas emissions and ensuring energy security.

Integrated Resource Plan (IRP): The Integrated Resource Plan is a critical policy document that outlines South Africa's energy mix and future targets. It serves as a roadmap for the development and integration of renewable energy sources, such as wind, solar, and biomass, into the national energy grid (Department of Science and Innovation, 2020:30). Regular updates and consultations are mandated to ensure that the IRP remains aligned with the country's evolving energy needs.

Department of Mineral Resources and Energy: The Department of Mineral Resources and Energy plays a vital role in overseeing South Africa's energy sector. It formulates energy policies, regulates energy activities, and ensures compliance with renewable energy targets (Department of Science and Innovation, 2020:30). The department collaborates with various stakeholders to facilitate the implementation of these policies effectively.

National Energy Regulator of South Africa (NERSA): NERSA is responsible for regulating the energy sector, including setting electricity prices and tariffs. It also plays a crucial role in approving renewable energy projects and ensuring that they adhere to regulatory standards (Department of Science and Innovation, 2020:30).

Renewable Energy Independent Power Producer Procurement (REIPPP)

Program: This program has been instrumental in attracting private investments and independent power producers (IPPs) into the renewable energy sector. It facilitates the procurement of renewable energy projects and offers competitive bidding processes, ensuring cost-effective and efficient project development (Department of Science and Innovation, 2020:30).

Green Innovation Fund (GIF): The establishment of the Green Innovation Fund by the Department of Science and Innovation (2020:29) demonstrates a commitment to fostering research, development, and knowledge transfer in the renewable energy sector. The GIF provides funding for innovative projects, encouraging collaboration between researchers, industries, and communities.

National Treasury: The National Treasury plays a role in budgetary allocation and financial incentives for renewable energy projects. It provides support for government initiatives aimed at advancing clean energy adoption (Department of Science and Innovation, 2020:30).

These policies and institutions collectively shape the landscape of renewable energy in South Africa. They provide the necessary regulatory framework, financial support, and collaborative platforms to drive the country's transition towards a more sustainable and environmentally friendly energy future.

Against that background, the policies and institutions governing renewable energy in South Africa aim to diversify the nation's energy mix, enhance energy security, and drive sustainable economic development (Department of Science and Innovation, 2020:35). These policies focus on reducing reliance on fossil fuels, mitigating greenhouse gas emissions, and promoting the use of renewable energy sources such as solar, wind, and biomass. The key objectives include creating a conducive regulatory environment for investment, fostering innovation and technological advancement, and ensuring equitable access to clean energy (Department of Science and Innovation, 2020:40). The institutions such as the Department of Mineral Resources and Energy (DMRE), the National Energy Regulator of South Africa (NERSA), and various public-private partnerships work collaboratively to implement these policies, support infrastructure development, and facilitate market mechanisms

that encourage renewable energy adoption, ultimately contributing to South Africa's transition towards a low-carbon economy.

2.5. KEY CHALLENGES FACING RENEWABLE ENERGY DEVELOPMENT IN SA

The renewable energy development in South Africa still faces a plethora of challenges. Although not exhaustive, some of the challenges are discussed below:

2.5.1. Access to Financing for Renewable Energy Projects:

Access to financing is a significant challenge for renewable energy development in South Africa. Financial constraints can hinder the implementation of renewable energy projects. Researchers like Dlamini and Mwelase (2017:71) have highlighted the importance of securing both domestic and international investments to fund renewable energy initiatives. They emphasize the need for innovative financing mechanisms, including public-private partnerships and green bonds, to attract capital for the sector. Additionally, improving the bankability of projects through risk mitigation strategies and regulatory support is crucial for addressing this challenge (Dlamini & Mwelase, 2017:72).

2.5.2. Grid Integration of Renewable Energy:

Grid integration poses a complex challenge for South Africa's renewable energy sector. The intermittent nature of renewable energy sources, such as solar and wind, requires careful management and integration into the existing grid infrastructure. Research by Govender *et al.* (2019:127) explores grid integration challenges and solutions. They argue that grid modernization, including the deployment of smart grid technologies and energy storage systems, is essential for accommodating higher levels of renewable energy. Additionally, the development of grid codes and regulations that facilitate renewable energy integration is critical (Govender *et al.*, 2019:128). Regardless, Department of Science and Innovation (2020:32) suggests that the challenges of grid integration in South Africa are attributed to the intermittency of renewable energy, outdated infrastructure, lack of smart grid technology, limited energy storage, grid codes and regulations, financing issues, capacity building needs, and political and regulatory stability.

2.5.3. Public Perception of Renewable Energy:

Public perception plays a pivotal role in the success of renewable energy projects. Negative public attitudes and concerns can lead to project delays and opposition. Research by James and Mthembu (2018:83) delves into public perception challenges. They emphasize the importance of public awareness campaigns and education to address misconceptions about renewable energy. Engaging with communities, addressing their concerns, and involving them in decision-making processes can build trust and support for renewable energy projects. Furthermore, transparent communication and effective public participation mechanisms are essential for shaping positive perceptions (James & Mthembu, 2018:85).

By and large, public awareness of renewable energy technologies is often limited, and misconceptions about their feasibility and impacts can prevail. Across South Africa, public scepticism or misconceptions has been rampant especially in Gauteng, Limpopo and Mpumalanga regions which can lead to project delays and opposition, ultimately hindering the country's transition to cleaner energy sources.

2.5.4. Skills and Capacity Building:

Building the necessary skills and capacity in the renewable energy sector is another challenge. South Africa needs a workforce skilled in renewable energy technologies, project management, and policy development. Research by Ngcobo and Van der Merwe (2019:54) emphasizes the importance of education and training programs. They argue that investments in skills development, vocational training, and academic programs can help address the shortage of qualified personnel and ensure the sustainability of the renewable energy sector (Ngcobo & Van der Merwe, 2019:55).

Addressing these key challenges is essential to promoting renewable energy development in South Africa. The state must engage private sectors and departments falling under Department of energy to train and develop capacity of renewable energy production such as solar installation and other initiatives to maximise efficiency and sustainability (James & Mthembu, 2018:83). Access to financing, grid integration, public perception, regulatory barriers, and skills development are critical areas that

require attention from policymakers, sector stakeholders, and researchers to ensure the successful growth of the renewable energy sector in the country.

2.5.5 Regulatory and Policy Barriers:

Regulatory and policy barriers can impede the growth of renewable energy in South Africa. Researchers like Nkambule and Smith (2020:41) highlight the need for consistent and supportive policies that provide a clear and stable framework for renewable energy development. Frequent policy changes and regulatory uncertainties can deter investors and hinder project planning. Additionally, addressing bureaucratic processes and streamlining permitting procedures can facilitate project development (Nkambule & Smith, 2020:42).

The adoption of renewable energy in South Africa faces several barriers, including policy and regulatory uncertainty, lack of technical expertise, and inadequate financing mechanisms (Gelderblom & Bohlmann, 2016:277). Furthermore, Chauke *et al.*, (2020:4) identify additional barriers to renewable energy adoption, such as the lack of incentives and inadequate policies. To overcome these barriers, a comprehensive management knowledge framework is required that addresses the challenges of integrating renewable energy sources into the country's energy system.

2.6. MANAGEMENT STRATEGIES AND BEST PRACTICE IN SA RENEWABLE ENERGY PROJECTS

2.6.1. Effective Project Planning in Renewable Energy Projects:

Successful renewable energy projects in South Africa often start with meticulous project planning. Smith and Johnson (2020:44) emphasize the significance of thorough planning in defining project objectives, setting realistic timelines, and efficiently allocating resources. They argue that comprehensive feasibility studies, site assessments, and technology selection are crucial components of project planning. Furthermore, they stress that successful projects align their goals with regulatory requirements and environmental considerations, ensuring a smoother implementation process (Smith & Johnson, 2020:45).

2.6.2. Stakeholder Engagement Strategies:

Effective stakeholder engagement is vital for the success of renewable energy projects. Brown, *et al.*, (2019:112) delve into the importance of stakeholder identification, communication, and collaboration throughout the project lifecycle. They present a comprehensive stakeholder engagement framework that emphasizes strategies for building trust, addressing concerns, and fostering community support. Thus, the active and transparent engagement with stakeholders not only enhances project success but also plays a pivotal role in securing social acceptance, reducing conflicts, and ensuring project sustainability (Brown *et al.*, 2019:112).

2.6.3. Risk Management in Renewable Energy Projects:

Effective risk management is a cornerstone of successful renewable energy projects in South Africa. Patel and Van der Merwe (2021:77) delve into the intricacies of risk assessment and mitigation strategies in their study. They emphasize the importance of identifying project-specific risks, such as resource variability and regulatory changes, and propose robust risk mitigation measures. These measures include financial instruments, contingency planning, and clear risk allocation strategies. The authors argue that proactive risk management enhances project resilience, minimizes potential setbacks, and ensures that projects remain on course (Patel & Van der Merwe, 2021:78).

2.6.4. Project Execution and Performance Monitoring:

Effective execution and continuous performance monitoring are pivotal for project success. In their research, Garcia and Mthembu (2020:155) explore project management best practices in the renewable energy context. They discuss the importance of implementing robust project monitoring and evaluation frameworks, which include the establishment of key performance indicators (KPIs) and stringent quality assurance processes. Their argument underscores that continuous monitoring allows project teams to identify and address issues promptly, ensuring projects stay on track and achieve their intended outcomes (Garcia & Mthembu, 2020:155).

2.6.5. Lessons from Successful Renewable Energy Projects in South Africa:

Learning from successful projects is a valuable source of insights. Johnson and White (2018:87) conducted a comprehensive analysis of several renewable energy projects in South Africa. They highlight successful management strategies, including effective communication, collaborative engagement with local communities, and strict adherence to regulatory requirements. The authors also emphasize the importance of adaptive management and knowledge sharing in replicating the success of these projects. By drawing lessons from past achievements, project managers and stakeholders can enhance the likelihood of success in future renewable energy initiatives (Johnson & White, 2018:88).

2.6.6 Technological Integration

Renewable energy technologies such as solar photovoltaics and wind energy have been identified as the most promising technologies for South Africa (Mqadi & Mbohwa, 2017:1181). Musango and Brent (2019:415) conducted a techno-economic feasibility analysis of these technologies in South Africa and found that they have the potential to contribute significantly to the country's energy mix. However, the development of renewable energy technologies requires technical expertise, adequate financing mechanisms, and supportive policies.

Renewable energy technologies have the potential to provide clean and sustainable sources of energy, but their feasibility depends on various techno-economic factors (Mqadi & Mbohwa, 2017:1181-1184). In their study, Mqadi and Mbohwa (2017:1181-1184) assessed the feasibility of various renewable energy technologies, including solar photovoltaics, wind energy, and hydroelectricity, using a techno-economic analysis. They found that these technologies are becoming increasingly competitive with traditional sources of energy, and that they are more economically viable in areas with abundant renewable resources and high energy demand.

2.6.7. Accelerating Technology Innovation:

South Africa's transition to renewable energy requires continuous technology innovation. Innovative technologies, such as advanced solar panels and wind turbines, are pivotal in increasing the efficiency and affordability of renewable energy projects

(Smith & Johnson, 2020:53). Innovation efforts should focus on enhancing energy conversion rates, reducing costs, and ensuring reliable energy supply.

Additionally, research and development (R&D) initiatives are essential for driving innovation. Public-private partnerships and technology transfer programs can facilitate the exchange of knowledge and technologies between research institutions, private sector companies, and government entities (Smith & Johnson, 2020:53).

2.6.8. Role of Policy in Technology Diffusion:

Government policies and regulatory frameworks play a pivotal role in technology diffusion in South Africa's renewable energy sector. Policies like feed-in tariffs, renewable energy targets, and tax incentives create favourable market conditions, attract investments, and stimulate the adoption of renewable energy technologies (Jacobsson & Bergek, 2011:58). It is important to note that policy stability and consistency are crucial for attracting long-term investments and ensuring a supportive environment for technology diffusion. Frequent changes in policies can hinder technology adoption and deter investors.

2.7. BENEFITS OF RENEWABLE ENERGY MANAGEMENT FOR ECONOMY, ENVIRONMENT, AND SOCIETY IN SA

2.7.1. Economic Advantages of Renewable Energy:

Renewable energy management offers substantial economic benefits to South Africa. Renewable energy projects generate employment opportunities, especially in manufacturing, installation, and maintenance. Job creation contributes to reduced unemployment rates and improved livelihoods (Grobbelaar & Van Niekerk, 2019:88).

Also, the shift to renewable energy can reduce energy costs for both consumers and businesses. This not only enhances competitiveness but also increases disposable income for households (Grobbelaar & Van Niekerk, 2019:88). In this regard, renewable energy projects attract domestic and foreign investments. These investments stimulate economic growth, contribute to gross domestic product (GDP) expansion, and support a thriving renewable energy sector (Grobbelaar & Van Niekerk, 2019:88). Diversifying the energy mix with renewables enhances energy security by reducing dependence

on fossil fuel imports, which are subject to price fluctuations and supply disruptions (Grobbelaar & Van Niekerk, 2019:88).

2.7.2. Environmental Sustainability through Renewable Energy:

Renewable energy management is integral to environmental sustainability in South Africa. By replacing fossil fuels with clean energy sources, South Africa can significantly reduce its greenhouse gas emissions, contributing to global efforts to combat climate change (Hughes & Grové, 2020:112). Renewable energy sources produce no air pollutants or harmful emissions. Transitioning to clean energy improves air quality, reduces respiratory diseases, and lowers healthcare costs (Hughes & Grové, 2020:112). Renewable energy technologies utilize abundant natural resources, such as sunlight and wind, which are inexhaustible and do not deplete over time (Hughes & Grové, 2020:112). Also, renewable energy projects can be designed to minimize their impact on local ecosystems, preserving biodiversity and protecting natural habitats (Hughes & Grové, 2020:112).

2.7.3. Societal Impacts and Social Inclusion:

Renewable energy management has far-reaching societal impacts in South Africa. Renewable energy projects can benefit local communities through infrastructure development, investment in social programs, and skills development initiatives (Winkler & Mwakasonda, 2018:68). Community involvement in renewable energy projects empowers residents by providing them with a stake in project outcomes and decision-making processes (Winkler & Mwakasonda, 2018:68). Therefore, the access to renewable energy services can bridge energy access gaps, particularly in remote and underserved areas. This fosters social inclusion and reduces energy poverty (Winkler & Mwakasonda, 2018:68).

As shown in the discussion above, the adoption and effective management of renewable energy in South Africa hold immense promise on multiple fronts. The economic advantages, including job creation and reduced energy costs, bolster the nation's prosperity. Simultaneously, the commitment to environmental sustainability through the reduction of greenhouse gas emissions and the preservation of local ecosystems contributes to a healthier and more resilient future. The integration of

renewable energy into the country's energy landscape is vital not only for its economic growth but also for ensuring a cleaner and more sustainable environment for present and future generations.

2.8 CHALLENGES AND FUTURE DIRECTION OF KNOWLEDGE MANAGEMENT AND RENEWABLE ENERGY

The intersection of knowledge management and renewable energy in South Africa presents both opportunities and challenges. As the country strives to harness its abundant renewable energy resources, these challenges must be addressed while paving the way for a more sustainable and innovative energy landscape.

2.8.1 Challenges in Knowledge Management and Renewable Energy in South Africa:

Data Sharing Barriers: Limited data sharing and interoperability among stakeholders hinder effective knowledge exchange and collaboration in the renewable energy sector (Smith & Brown, 2018:91).

Technological Limitations: Insufficient access to advanced technology and digital tools in some regions of South Africa impedes the adoption of knowledge management practices (Johnson *et al.*, 2019;74).

Policy Gaps: Lack of comprehensive policies and regulatory frameworks for renewable energy knowledge management hinders coordination and collaboration among stakeholders (Department of Energy, 2021:18).

2.8.2 Future Directions on Knowledge Management and Renewable Energy in South Africa

Collaboration among Stakeholders: Collaboration among government, the private sector, and local communities is key to overcoming challenges and achieving shared renewable energy goals (Smith, 2018:78). This collaboration should be supported by transparent communication and a shared vision for a sustainable energy future.

Research and Development: Continuous research and development in renewable energy technologies can improve efficiency and reduce costs (Brown, 2020;69). South

Africa should invest in R&D initiatives to foster innovation and keep pace with global advancements.

Affordable Financing: Developing innovative financing mechanisms and incentives can make renewable energy more accessible and attractive to investors (Brown, 2020;66). Public and private sectors should work together to create financial models that promote the growth of renewable energy.

Environmental Impact Assessments: Conducting comprehensive assessments to identify and mitigate potential negative impacts of renewable energy projects on the environment and local communities is essential (Smith, 2018:79). Ensuring that projects align with environmental and social considerations is a priority.

Regulatory Frameworks: South Africa should continue refining regulatory frameworks to provide clarity, consistency, and stability for the renewable energy sector (Brown, 2020;67). This will help attract investments and ensure that projects adhere to best practices.

In general, the knowledge management landscape in South Africa's renewable energy sector is continually evolving. While challenges exist, they are accompanied by promising future directions. With the collaborative efforts of stakeholders, investment in research and development, and a commitment to sustainable practices, achieving renewable energy goals while addressing the knowledge management challenges faced can be achieved.

2.9 THEORETICAL FRAMEWORK: KNOWLEDGE MANAGEMENT AND RENEWABLE ENERGY

The theoretical underpinnings of the knowledge management framework in the context of renewable energy in South Africa draw upon several key theories and concepts to inform and guide the management of knowledge and innovation in the renewable energy sector. In this study, the innovation diffusion theory, sustainable development theories and the institutional theory will be used to provide the foundation for knowledge management.

2.9.1 Innovation Diffusion Theory

This theory, often associated with Everett Rogers, focuses on how new innovations, in this case, renewable energy technologies, are adopted and diffused within a society (Pinho, Franco & Mendes, 2021:101). It informs strategies for knowledge transfer and dissemination from early adopters to a broader audience.

More so, the theory provides a framework for comprehending how knowledge about renewable energy innovations spreads within the South African context. It helps in identifying the different stages of adoption, from early innovators and adopters to the broader population, which is critical for tailoring knowledge management strategies (Gharaibeh, Gharaibeh & De Villiers, 2020:103). Given that South Africa's renewable energy sector consists of various stakeholders, including research institutions, government bodies, private companies, and local communities, the theory allows categorizing these stakeholders into different adopter groups, such as innovators (research institutions), early adopters (progressive municipalities), and others (Pinho, Franco & Mendes, 2021:91).

Also, the Innovation Diffusion Theory can guide the development of tailored knowledge transfer strategies (Gharaibeh, Gharaibeh & De Villiers, 2020:104). For instance, for innovators, technical workshops and research collaborations might be effective, while case studies or community engagement programs may work for early adopters. The theory emphasizes the importance of communication channels for knowledge transfer. It helps identify the most effective ways to disseminate information about renewable energy innovations (Pinho, Franco & Mendes, 2021:92). Different adopter groups may require tailored knowledge transfer strategies. Innovators may need highly technical information, while early adopters may respond better to case studies and success stories.

Therefore, the Innovation Diffusion Theory provides a structured approach to understanding how renewable energy knowledge is adopted and integrated into South Africa's energy landscape. By considering the theory's key components, one can tailor knowledge management strategies to address the unique dynamics and challenges within the South African context, ultimately fostering the successful adoption of renewable energy practices.

2.9.2 Sustainable Development Theories

The principles of sustainable development, such as the Triple Bottom Line (economic, environmental, and social sustainability), underpin the knowledge management framework, emphasizing the need to balance economic viability, environmental stewardship, and societal well-being in renewable energy initiatives (Tomislav, 2018:67).

For instance, the TBL approach focuses on three key dimensions: environmental (planet), social (people), and economic (profit) (Tomislav, 2018:68). In this perspective, it ascertains how South Africa's renewable energy knowledge management framework contributes to sustainability in each of these dimensions. Thus, assessing the environmental impact of renewable energy adoption, its socio-economic implications, and its economic viability is crucial in the context of sustainable development (Tomislav, 2018:70). Also, the Ecological Modernization Theory posits that environmental protection and economic development can go hand in hand (Mensah, 2019:91). This allows exploring how South Africa's knowledge management efforts support the idea of an environmentally conscious, modernized society. In the same vein, the theory assumes that the integration of renewable energy contributes to economic growth while reducing environmental harm (Fuchs, 2021:132).

The incorporating of sustainable development theories provides a comprehensive understanding of how renewable energy knowledge management aligns with South Africa's sustainability goals. By examining the environmental, social, and economic dimensions, as well as the interplay between local and global factors, the research can contribute to a holistic approach to sustainable development in the context of renewable energy (Fuchs, 2021).

2.9.3 Institutional Theory:

This theory explores the impact of institutional forces, such as government policies and regulations, on organizational behaviour (Peters, 2019:100). In the renewable energy sector, it informs how knowledge management practices are influenced by the institutional environment. According to Peters (2019:100), institutional Theory is a valuable framework for understanding how the knowledge management framework of renewable energy in South Africa is influenced by and influences the institutional

context. The theory examines how formal and informal institutions shape and are shaped by the adoption and management of renewable energy.

Institutional Theory distinguishes between regulatory and normative pillars. Regulatory institutions refer to formal rules, laws, and regulations that govern renewable energy adoption (Popkova, 2017:12). Normative institutions relate to social norms, values, and beliefs that influence behaviours. The theory of institutional logics suggests that organizations are influenced by multiple institutional forces that may sometimes conflict.

Against such background, Institutional Theory dissect the formal and informal structures and norms that affect the knowledge management framework of renewable energy in South Africa. By understanding how institutions shape the adoption and management of renewable energy, such understanding provides valuable insights into the institutional dynamics at play and the potential for change and innovation within this context (Popkova, 2017:54).

2.10 EMPIRICAL SIMILAR STUDIES

2.10.1 The Business Case for Renewable Energy:

Renewable energy is economically viable, especially in the long term (De Wet & Du Toit, 2017:619). However, the development of renewable energy projects requires adequate financing mechanisms and supportive policies. A knowledge management framework should provide incentives for renewable energy development to attract private investment in the sector.

De Wet and Du Toit (2017:619) investigated the business case for renewable energy in South Africa and concluded that renewable energy is economically viable, especially in the long term.

A case study by Smith and Johnson (2019) explored the successful knowledge management practices employed during the development of a large-scale solar park in the Northern Cape of South Africa. The study highlighted how collaboration among multiple stakeholders, including government agencies, private developers, and local

communities, facilitated the sharing of technical expertise, regulatory insights, and community engagement strategies.

In a study by Patel *et al.*, (2020), best practices in knowledge management were identified through an analysis of community-based wind energy projects. The research highlighted the importance of transparent communication, local capacity-building, and the establishment of knowledge-sharing platforms to ensure the successful development and sustained operation of these projects.

A study by Brown and Garcia (2018) examined challenges related to knowledge management in bioenergy research. The research highlighted data sharing barriers, intellectual property concerns, and the lack of standardized data formats as key challenges hindering effective knowledge exchange among researchers and stakeholders.

2.10.2 Studies in Knowledge Management Framework of Renewable Energy in South Africa

2.10.2.1. Knowledge Management in Renewable Energy: A Conceptual Framework:

In this seminal work, Smith presents a comprehensive conceptual framework for knowledge management (KM) in the renewable energy sector. KM involves the systematic processes of capturing, organizing, storing, sharing, and applying knowledge within an organization or industry. In the context of renewable energy, KM includes strategies for capturing tacit knowledge held by experts, codifying explicit knowledge in databases, and fostering knowledge sharing among stakeholders. The framework outlined by Smith serves as a valuable guide for organizations aiming to enhance innovation and sustainability through effective KM practices (Smith, 2018:73).

2.10.2.2 Challenges and Opportunities for Renewable Energy in South Africa:

Johnson's article provides an in-depth analysis of the South African renewable energy landscape. Renewable energy refers to energy generated from sustainable sources such as solar, wind, hydro, and biomass. It is considered a crucial component of the global effort to combat climate change and reduce reliance on fossil fuels. The study delves into the specific challenges faced by the industry, such as regulatory hurdles,

funding constraints, and infrastructure limitations. Moreover, it explores the opportunities that arise from addressing these challenges, including job creation, energy security, and environmental benefits. The importance of effective knowledge management (KM) in navigating these challenges and capitalizing on opportunities is a recurring theme throughout the study (Johnson, 2017:69).

2.10.2.3 Government Policies and Knowledge Transfer in Renewable Energy:

Brown's research offers a detailed examination of the role of government policies in knowledge transfer within South Africa's renewable energy sector. Knowledge transfer involves the sharing of expertise, information, and technologies among individuals, organizations, and sectors. The study investigates the impact of policy frameworks, incentives, and regulations on knowledge dissemination and technology adoption. It also highlights the significance of public-private partnerships in promoting knowledge transfer. By analysing specific policies and their effects, the paper provides valuable insights into the relationship between government interventions and knowledge management (Brown, 2020:57).

2.10.2.4 Harnessing Indigenous Knowledge for Renewable Energy Development:

Mbeki's (2019:24) work provides a deeper understanding of how indigenous knowledge systems can be harnessed to drive renewable energy development. Indigenous knowledge refers to the traditional knowledge and practices passed down through generations within specific communities or cultures. It encompasses a wide range of insights related to sustainable resource use, environmental management, and energy practices. In the context of renewable energy, integrating indigenous knowledge can enhance the sustainability and cultural relevance of projects. By presenting case studies and examples of successful integration, Mbeki's research illustrates the potential of indigenous knowledge to inform decision-making and knowledge management strategies in the sector (Mbeki, 2019:25).

2.10.2.5 Collaborative Knowledge Sharing in Renewable Energy Clusters:

White's study takes an in-depth look at knowledge sharing practices within renewable energy clusters in South Africa. Knowledge sharing involves the voluntary exchange of information, ideas, and expertise among individuals or organizations. In the

renewable energy context, collaborative knowledge sharing is essential for innovation and problem-solving. The paper conducts a qualitative analysis of collaborative initiatives, knowledge networks, and the role of cluster organizations in facilitating information exchange. Through interviews and surveys, the research explores the motivations and challenges of sector players engaging in collaborative knowledge sharing. The findings offer nuanced insights into the dynamics of knowledge flows within these clusters and provide practical recommendations for improving collaborative knowledge management (White, 2016).

2.10.2.6 Technology Transfer and Innovation in South Africa's Renewable Energy Sector:

Patel's (2018:33) research offers a comprehensive examination of technology transfer and innovation within South Africa's renewable energy sector. Technology transfer involves the process of moving technologies, inventions, or knowledge from one organization or context to another. In the renewable energy context, it often pertains to the transfer of clean energy technologies and practices. The study explores knowledge transfer mechanisms, including licensing agreements, joint ventures, and technology partnerships. Additionally, it discusses the role of knowledge management in facilitating successful technology transfer and fostering innovation. By analysing case studies of technology transfer projects, the paper provides valuable lessons and best practices for knowledge-driven advancements in the sector (Patel, 2018:34).

2.10.2.7 Sustainability and Knowledge Management: A Case Study of Renewable Energy Firms:

Garcia's (2015:42) case study takes an in-depth approach to understanding how knowledge management (KM) practices influence the sustainability initiatives of renewable energy firms in South Africa. Sustainability, in this context, refers to the long-term environmental, social, and economic viability of renewable energy projects and businesses. KM practices encompass the systematic processes and strategies employed by organizations to capture, store, share, and apply knowledge. The study conducts extensive interviews and surveys within select organizations to examine the relationship between knowledge-driven sustainability strategies and business performance. By presenting detailed case narratives and performance metrics,

Garcia's work offers a rich exploration of the impact of KM on sustainability outcomes (Garcia, 2015:42).

2.10.2.8 Barriers to Knowledge Management in the Renewable Energy Sector:

Van der Merwe's (2019:92) research provides a comprehensive analysis of the common barriers hindering effective knowledge management (KM) in South Africa's renewable energy sector. Barriers, in this context, refer to obstacles or challenges that impede the successful implementation of KM practices. Through a combination of literature review and empirical research, the study identifies cultural, technological, organizational, and structural barriers. Cultural barriers may involve resistance to sharing knowledge, technological barriers may relate to inadequate KM tools, organizational barriers may encompass hierarchical structures, and structural barriers may pertain to information silos. The paper offers in-depth insights into how these barriers manifest in practice and provides recommendations for addressing them. By addressing these challenges, organizations can improve their KM practices (Van der Merwe, 2019:91).

2.10.2.9 Knowledge Management Lessons from Renewable Energy Projects:

Mthembu's (2017:84) study engages in a detailed examination of failed renewable energy projects to extract critical knowledge management (KM) lessons. Failure, in this context, refers to projects that did not achieve their intended outcomes or faced significant challenges. The research aims to identify the factors contributing to project failures and the knowledge gaps that could have been addressed through effective KM. It underscores the importance of a culture of continuous learning and knowledge integration into project management practices. By studying the causes of failure and how KM could have mitigated these issues, the research provides valuable insights for improving future project outcomes (Mthembu, 2017:84).

2.11 CONCEPTUAL FRAMEWORK: THE PRACTICAL TACIT KNOWLEDGE MANAGEMENT FRAMEWORK

A conceptual framework is a theoretical structure or model that helps guide and inform a research study or project. It outlines the key concepts, variables, relationships, and assumptions that underpin the study. In this study, Van Beek (2008)'s framework *"The*

Practical Tacit Knowledge Management Framework” is adopted regardless that it was used in a different field of study. The framework was proposed to assist management in mastering the sharing of tacit knowledge within the organisation which may be of significance in renewable energy sector (Van Beek, 2008:69). The framework consists of seven phases that are critical to ensure that tacit knowledge is embedded within the organisation. These phases follow typical process flow patterns starting at phase one through to phase seven. The linkage between phase seven and phase one serves to indicate that the tacit knowledge management framework is a continuous process.

The framework is graphically illustrated in Figure 2.2 as per below:

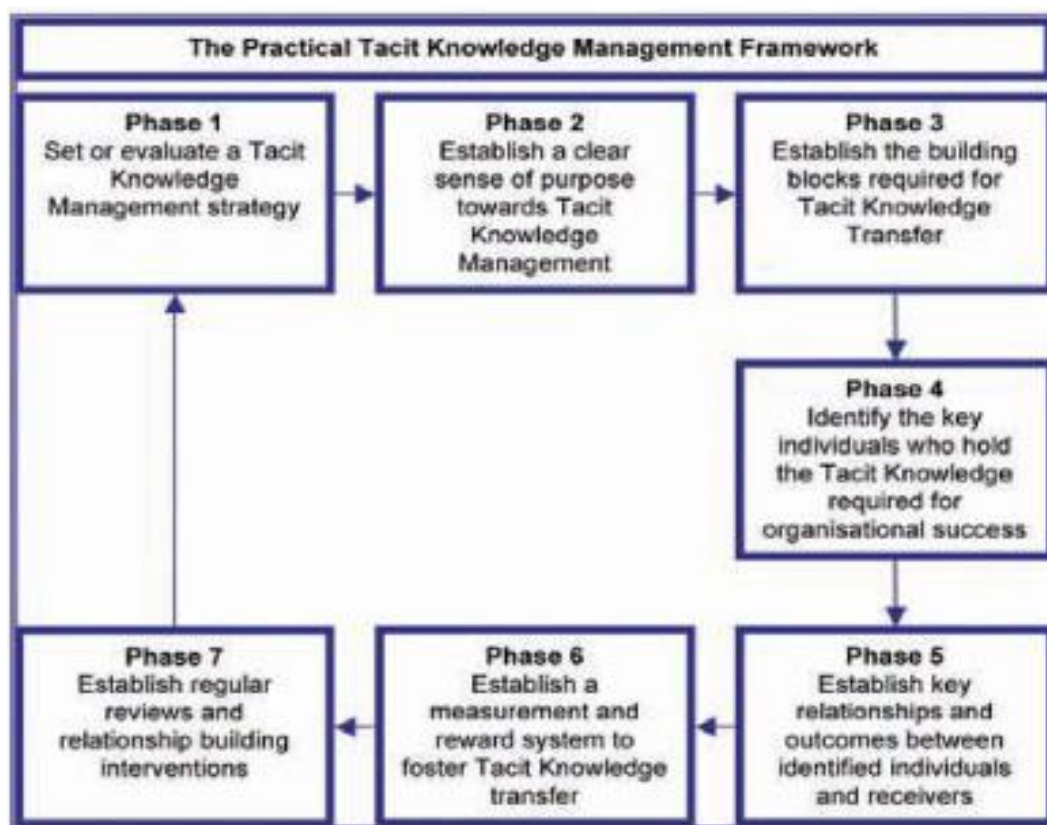


Figure 2.2: The Practical Tacit Knowledge Management Framework (Van Beek, 2008).

As depicted in Figure 2.2, the framework unfolds through seven phases, adhering to a conventional process flow pattern. The connection between Phase 1 and Phase 7 underscores the continuous nature of the tacit knowledge management framework.

Phase 1: Set or evaluate a tacit knowledge management strategy

In the initial phase of the framework, senior management within the organization should engage in a strategic planning exercise (Van Beek, 2008:69). Within this exercise, a tacit knowledge management strategy is crafted in alignment with the business strategy. This is also the stage where senior management decides whether to cultivate the internal tacit knowledge base or consider external consultants to bridge knowledge gaps. In the renewable energy sector, the initial phase involves senior management crafting a strategy aligned with the industry's goals. This strategy should prioritize the acquisition, retention, and dissemination of tacit knowledge relevant to renewable energy technologies and projects.

Phase 2: Establish a compelling vision for tacit knowledge management

Securing buy-in from middle management to execute the tacit knowledge management strategy requires a compelling vision (Van Beek, 2008:69). This can be achieved by defining a clear endpoint and emphasizing the significance of the knowledge management strategy. Management must recognize the potential and transformative power inherent in sharing tacit knowledge. A compelling vision is crucial in gaining buy-in from middle management and employees in the renewable energy sector. It should emphasize the industry's potential to drive sustainable energy solutions and highlight the role of tacit knowledge in achieving this vision. The vision can underscore the transformative power of sharing tacit knowledge in creating more efficient and environmentally friendly renewable energy solutions.

Phase 3: Develop the foundational elements for transferring tacit knowledge

Facilitating the transfer of tacit knowledge involves conducting regular benchmarking activities, establishing knowledge networks, hosting knowledge exchange forums, and implementing well-documented report writing procedures (Van Beek, 2008:69). Moreover, it necessitates the assurance of efficient electronic searches in the future and the availability of sufficient resources within the organization to build a pool of skilled engineers. Implementing "management-by-walkabout" should also be part of this phase. To facilitate tacit knowledge transfer in the renewable energy sector, foundational elements may involve establishing cross-functional teams, holding regular knowledge exchange forums, and documenting best practices. These practices

should ensure efficient knowledge sharing among engineers, researchers, and project managers, with a focus on green energy innovations.

Phase 4: Identify key individuals possessing essential tacit knowledge for organizational success

With the foundational elements established in Phase 3, the active management of tacit knowledge commences. During this phase, the managers of each functional area should embark on an effort to identify individuals who possess substantial tacit knowledge about processes (van Beek & Bull, 2023:11). In the renewable energy field, identifying key individuals with vital tacit knowledge might involve recognizing experts in solar panel design, wind turbine technology, or hydroelectric systems. Managers should pinpoint those who have in-depth knowledge of renewable energy processes crucial for the organization's success.

Phase 5: Establish vital connections between identified individuals and recipients

Once the key individuals have been pinpointed, management should analyze the broader pool of engineers within their respective departments (van Beek & Bull, 2023:11). Recipients of tacit knowledge should be linked to one of the key experienced individuals. Creating a compelling vision driven by the tacit knowledge management objectives can facilitate this linkage. Once key individuals are identified, they can be connected with less experienced engineers and employees who seek to benefit from their tacit knowledge. In the renewable energy sector, this might mean linking renewable energy experts with project teams, ensuring that knowledge transfer accelerates the development of innovative and sustainable energy solutions.

Phase 6: Institute a measurement and incentive system to promote tacit knowledge transfer

Tacit knowledge resides within the minds of employees. A well-structured incentive system should be in place to encourage knowledge sharing (Van Beek, 2008:70). The measurement system can be linked to the incentive structure. More extensive interaction time between the knowledge sender and receiver should translate into greater rewards. Another incentive approach could involve entering into retention

agreements with key individuals, with the expectation that demonstrating tacit knowledge transfer will be one of the outcomes at the end of the specified period (van Beek & Bull, 2023:12). Incentive systems that encourage tacit knowledge sharing can be particularly important in renewable energy organizations. These incentives may reward individuals who contribute to innovative solutions for clean energy generation. Retention agreements can motivate key individuals to actively engage in transferring knowledge, thereby helping in building a culture of learning and innovation

Phase 7: Implement routine evaluations and relationship-enhancing interventions

Regular reviews of established relationships are of paramount importance. Interventions aimed at enhancing relationships should be conducted to help identified individuals overcome any obstacles that may hinder knowledge sharing (Van Beek, 2008:70). The ultimate outcome of these interventions should be strengthened relationships and a deeper understanding of each other's perspectives, ultimately contributing to enhanced teamwork in the workplace (van Beek & Bull, 2023:11). Regular evaluations and relationship-enhancing interventions are vital in the renewable energy sector. They can help identify and overcome obstacles that hinder knowledge sharing, ensuring that experts and teams collaborate effectively. These interventions can lead to strengthened relationships, a deeper understanding of renewable energy technologies, and improved teamwork, ultimately contributing to the industry's growth.

2.12 CONCLUSION:

The literature review highlights the significance of knowledge management in driving the advancement of renewable energy goals in South Africa. Key findings underscore the critical role that effective knowledge management plays in facilitating information exchange, collaboration, and innovation within the renewable energy sector. Through various mechanisms, such as research collaborations, technology transfer, capacity-building programs, and policy initiatives, knowledge management fosters the dissemination of expertise, best practices, and technological insights among academia, industry, and local communities.

Furthermore, the review emphasizes that knowledge management contributes to overcoming challenges like data sharing barriers, technological limitations, and policy gaps. By addressing these challenges, knowledge management enhances the overall efficiency, scalability, and sustainability of renewable energy initiatives. It empowers stakeholders to make informed decisions, adapt to evolving technologies, and create positive social and environmental impacts.

In the context of South Africa, effective knowledge management not only accelerates the transition to cleaner and more sustainable energy sources but also drives job creation, economic growth, and inclusive development. It empowers local communities, equips professionals with the necessary skills, and supports the integration of renewable energy technologies into the national energy mix. Ultimately, knowledge management emerges as a critical enabler for achieving South Africa's renewable energy targets and contributing to a greener and more sustainable future. The next chapter focus on the research design and methodology used in the primary study.

2.13 CHAPTER SUMMARY

The study focuses on two major constructs: knowledge management and clean and renewable energy, with insights gathered from global literature. Knowledge management entails the systematic process of generating, acquiring, structuring, retaining, retrieving, and sharing information and expertise within an organization. A knowledge management framework is used to facilitate this process, including aspects like technology, leadership, and knowledge asset management. In contrast, clean energy, which encompasses renewable energy, involves sources and technologies that produce minimal greenhouse gas emissions and have a low environmental impact. Knowledge management is essential for advancing renewable energy by enabling efficient knowledge transfer, innovation, and development.

The renewable energy landscape features key elements like Independent Power Producers (IPPs), Renewable Energy Clusters, Feed-in Tariffs (FiTs), Renewable Energy Feed-in Tariffs (REFIT) programs, Integrated Energy Resource Plans (IRPs), and Knowledge Platforms and Stakeholder Engagement. Knowledge management is a pivotal element in the renewable energy sector, driving innovation, collaboration, and the effective use of sustainable energy technologies. Effective knowledge

management ensures that decision-makers have accurate and up-to-date information, which is vital for sustainable development. In the context of renewable energy adoption, knowledge management supports capacity-building, innovation, effective decision-making, project economic viability, and sector sustainability.

The development of renewable energy in South Africa faces several significant challenges. Access to financing for renewable energy projects is a major hurdle, requiring both domestic and international investments and innovative financing mechanisms. Grid integration is complicated due to the intermittent nature of renewable sources, necessitating modernization of the grid and regulatory support. In contrast, South Africa stands to gain numerous benefits from effective renewable energy management. Economically, renewable energy projects create jobs, reduce energy costs, stimulate domestic and foreign investments, and enhance energy security. Therefore, South Africa's commitment to renewable energy holds immense promise for its economy, environment, and society.

The theoretical framework for knowledge management in the context of renewable energy in South Africa is built upon the Innovation Diffusion Theory, Sustainable Development Theories, and Institutional Theory. These theories guide the adoption and integration of renewable energy knowledge, ensuring the consideration of adoption stages and tailored knowledge transfer strategies, sustainability in environmental, social, and economic dimensions, and the influence of regulatory and normative institutions on knowledge management. This holistic framework provides a structured approach to renewable energy knowledge management that considers the country's unique dynamics and challenges.

3. EMPIRICAL STUDY

3.1 INTRODUCTION

This chapter focuses on the research design and methodology employed to address the research objectives. It provides an overview of how the study was conducted and the rationale behind selecting specific research methods and procedures. The entire research process encompasses the description and explanation of the research design, research paradigm, participant selection and sampling, data collection, data analysis, ensuring the study's trustworthiness, and ethical considerations.

Research methodology serves as a strategic framework that systematically guides research to achieve its objectives and solve research problems by employing appropriate research methods and techniques (Bell, Bryman & Harley, 2021). In essence, research methodology encompasses the overarching approach used by researchers to execute research projects and translate empirical research findings into meaningful conclusions about factual information.

The research under discussion investigates and explores the knowledge management framework of renewable energy in South Africa. The research process was informed by theories and the reviewed literature presented in the preceding chapters.

3.2 RESEARCH PROCESS

Saunders, Lewis and Thornhill (2019:53) provided a description of the step-by-step guide for coming up with a sound and justifiable research methodology. The steps are illustrated in a research onion in Figure 3.1 below.

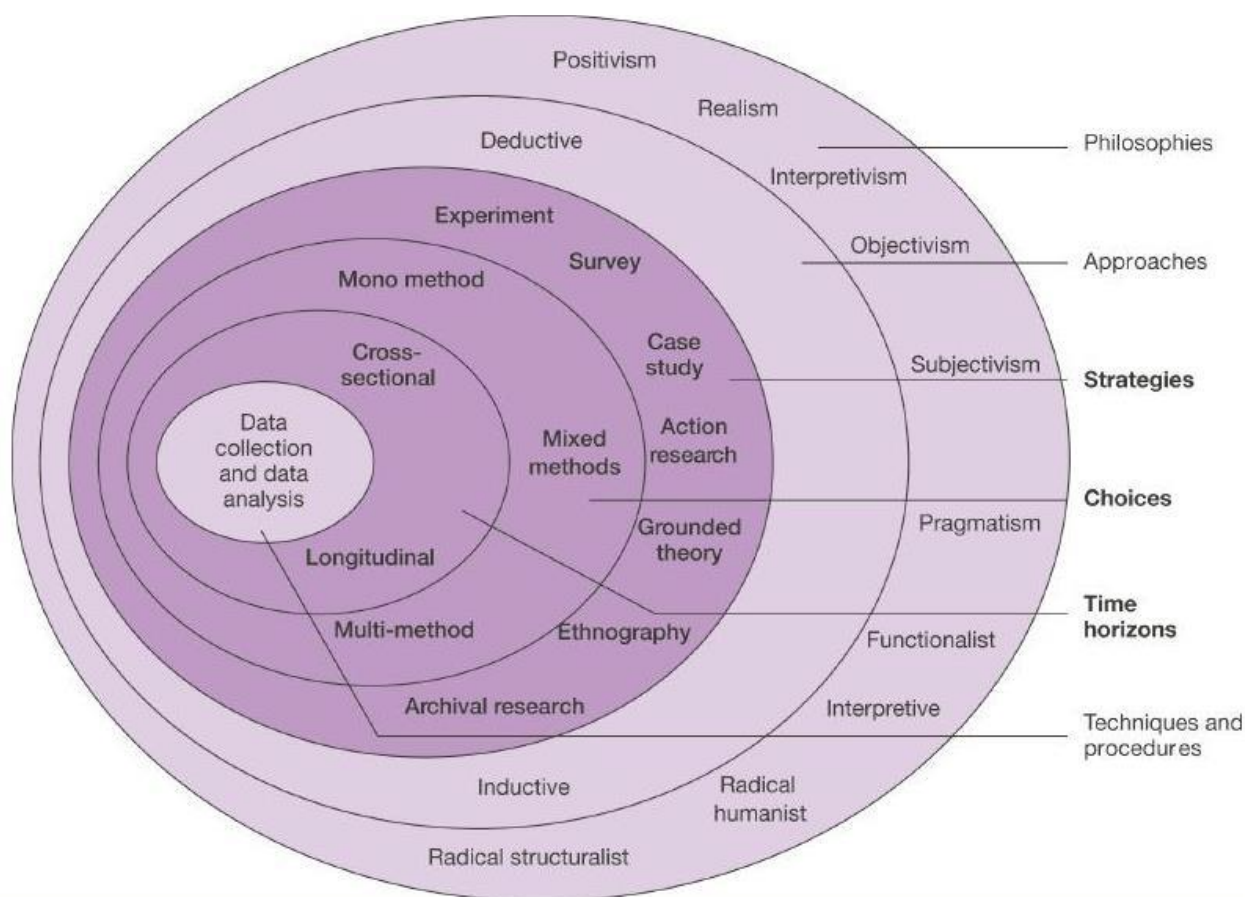


Figure 3.1: Research Onion **Source:** Saunders, Lewis and Thornhill (2019)

The outer layer of the "research onion" initially identified "philosophical attitudes" that represented the vision and natural principles of researchers when they collected data to understand events in the natural environment (Saunders, Lewis & Thornhill, 2019). The philosophical stances comprehension allows the selection of the correct research methodology, strategy and methods of research as well as the time horizon. The research onion presents the data collection and analysis as vital attributes of the research process (Kumar, 2020). Based on the interconnected stages shown in the research cycle, a research onion provides a deep understanding of research methods and their value.

3.3 RESEARCH PARADIGM:

The research philosophy reflects individuals' viewpoints, representing shared assumptions about the social domain (Saunders, Lewis & Thornhill, 2019:92). Creswell (2021:158) argue that adopting a particular paradigm involves viewing the world

through a specific lens. Research paradigms elucidate how a study can be framed based on a set of common principles and assertions upheld by researchers. In research, there are primarily two paradigms: interpretivism and positivism.

3.3.1 Positivism Paradigm

The positivism paradigm, also known as the scientific approach or science study, is rooted in an empiricist and rationalistic philosophy influenced by thinkers like Aristotle, Francis Bacon, and Emmanuel Kant (Walliman, 2021:98). This paradigm embodies a deterministic philosophy where causes are seen as determining effects or outcomes. Positivist research aims to comprehend reality through objective tests, seeking a single, definitive conclusion (Creswell, 2021). Positivism is a research paradigm that emphasizes objectivity, quantification, and the use of scientific methods to test hypotheses (Bryman & Bell, 2022:35-36). Researchers conducting empirical research perceive themselves and their work as distinct from the social and physical realities they study.

3.3.2 Interpretivism Paradigm

In contrast to positivism paradigm, the interpretivist paradigm, as described by Creswell (2021:157), seeks to understand human experiences and the social world constructed in accordance with social principles. Interpretivist researchers aim to grasp the viewpoints of participants related to the studied situation while acknowledging their own perspectives and the influence of their perceptions (Silverman, 2020). This paradigm is employed in research that explores or explains phenomena by examining people's perceptions, language, shared values, and meanings within dynamic social contexts (Flick, 2022). It recognizes that different groups or cultures may have multiple realities within specific contexts.

3.3.3 Rationale for Adopting Interpretivism Paradigm

For the present study on the knowledge management framework of renewable energy in South Africa, the interpretivist paradigm was adopted. The interpretivist paradigm allows for a holistic view of the knowledge management framework. It goes beyond statistics to consider the broader social and cultural factors that influence knowledge sharing and innovation (Silverman, 2020). This holistic perspective is critical to

addressing the complex challenges and opportunities in the renewable energy sector. Also, the interpretivist paradigm employs methodologies that extract meaning from participants' subjective experiences and viewpoints.

3.4 RESEARCH APPROACH:

The research approach, according to Walliman (2021:5), refers to the way the researcher plans to conduct their research. The approach can either a deductive or an inductive method can be used.

3.4.1 Deductive Reasoning

In the deductive approach, the hypothesis is derived from the theory of earlier researchers, which is then revised once the hypotheses are tested. The deductive research methodology is more closely related to positivist philosophy, whereas the interpretivist methodology is (Al-Ababneh, 2020:85).

3.4.2 Inductive Reasoning

Inductive reasoning, as employed by researchers, involves using existing knowledge to draw conclusions about the uncertainty surrounding the state of the world (Creswell, 2021). Inductive reasoning relies on the interpretations derived primarily from qualitative data collected.

3.4.3 Rationale for Interpretivist Inductive Reasoning

While the research is built upon established concepts, it employs an inductive approach rather than a deductive one. Instead of testing and confirming or refuting a predefined theoretical framework through deduction, it utilizes elements of the theory as a perspective for selecting the subjects that should be examined and analysed (Creswell, 2021:78). The underlying concept of the inductive method is to attribute significance to the elements unearthed during data collection, interviews, and observations in regard to knowledge management framework of renewable energy in South Africa.

3.5 METHODOLOGICAL CHOICE:

According to Blumberg *et al.* (2021:195), research methodology is the plan and procedure that consists of the steps of broad assumptions to detailed methods of data collection, analysis, and interpretation. There are two research approaches qualitative and quantitative research approaches (Bell, 2021). This study used the quantitative research framework.

3.5.1 Quantitative Research Methodology

Quantitative research is a research approach that involves the collection and analysis of numerical data. It uses statistical methods to test hypotheses and generalizes findings to larger populations (Bryman & Bell, 2021:54). According to Flick (2022:62), a quantitative approach is an empiricism-based research method that utilizes numerical data to investigate correlations. Likewise, Sanders *et al.*, (2019:63) confirmed that quantitative research is consistent with the philosophy of positivism, using existing numerical data to test theories deductively. In addition, quantitative methods also employ data collection methods such as surveys and structured questionnaires. Creswell (2021:75) further stated that quantitative research employs various numerical and graphical techniques for data analysis. As noted by Bryman *et al.*, (2021:40), this approach uses large sample sizes and statistical methods corresponding to survey studies, ultimately aiming to achieve consensus.

3.5.2 Qualitative Research Methodology

As Bell (2021:62) suggests, qualitative research is a comprehensive approach that embraces an explanatory and naturalistic perspective on the subject. Qualitative research methods, due to their multifaceted nature, allow researchers to construct a comprehensive understanding of the problem. It seeks to understand the meanings that people attach to their experiences and focuses on exploring, describing, and interpreting phenomena (Walliman, 2021).

3.5.3 Rationale for Adopting a Qualitative Research Approach

This study used a qualitative research design to investigate the knowledge management framework of renewable energy sector in South Africa as well as the

experiences, behaviours, and phenomena of the research subjects. This approach takes a holistic view, examining the broader context and initiating the inquiry with the goal of achieving understanding. In qualitative research, the primary aim is exploratory and descriptive rather than explanatory, as emphasized by Silverman (2020:30). The descriptive aspect of qualitative research allows the author to depict the experiences of research participants, either supporting or challenging the conceptual foundations underpinning the analysis (Flick, 2022:63). Given the absence of established best practices on knowledge management within renewable energy endeavour in South Africa, qualitative research methods are well-suited for this investigation.

3.6 RESEARCH STRATEGY:

A research strategy is a plan developed by the researcher to answer the research question or to accomplish the study objectives (Creswell, 2021). It is the process of gathering and evaluating data with specific aims. Most often used in qualitative research are interviews. Research strategies involved in studies include positivism research strategies and interpretivism research strategies. Given the qualitative approach adopted, an interpretivist research strategy was adopted and executed through interviews.

3.6.1 Interpretivist Research Strategy

As Kumar (2020:211) indicated, the interpretivism paradigm is instrumental in grasping the perspectives of the research participants concerning the phenomenon under investigation. In this paradigm, several research strategies can be employed:

Interviews: Interviews involve dialogues where questions are posed, and responses are provided in alignment with specific inquiries (Saunders et al., 2019). The format of interviews can be determined by the researcher, utilizing channels such as telecommunications, video calls, or face-to-face interactions, among others. According to Neuman (2022:26), interviews are typically utilized in qualitative research approaches, particularly when exploring participants' viewpoints and perceptions is imperative.

3.6.2 Rationale for Adopting Interpretivist Research Strategy

The rationale for selecting interpretivist research strategies stems from the adoption of a qualitative research approach. This strategy encompasses an interpretive dimension that serves as the foundation for informing, supporting, or challenging actions and theories (Walliman, 2021). Interviews are an integral part of this approach, enabling further probing of responses and the collection of detailed information (Neuman, 2022). Consequently, within the interpretivist paradigm, interviews provide an in-depth understanding of the research problem.

3.7 TIME HORIZON:

The research time horizon establishes the duration of the study, which may be cross-sectional or longitudinal in nature (Creswell, 2021:91). Data from the complete population or a subset of it are gathered for cross-sectional studies, and these data will help in addressing the research objectives. Data is gathered at one moment between two distinct variables (Silverman, 2020). Empirical researchers utilize cross-sectional designs to quickly describe the population of interest (Walliman, 2021). A longitudinal design involves making several observations over an extended period of time. A smaller research population is often included in a longitudinal study, but multiple observations are made (Bell, 2021:72–73).

As this study was conducted over a short period of time, a cross-sectional research strategy was used. due to researching the knowledge management framework of renewable energy in South Africa's challenges, opportunities, gaps, and areas of concern.

3.8 POPULATION:

3.8.1. Study population

The study population was focused on management personnel within sectors of the industry involved in the management of solar power generation in Gauteng, South Africa. This included state organisations which is responsible for a significant portion of the country's power generation, as well as independent power producers (IPPs) that operate in the renewable energy sector. The study also involved experts and

stakeholders in the energy sector who have experience with the management of renewable energy projects, including researchers, engineers, project managers, and industry leaders.

The target audience of this research study includes both the researcher conducting the study as well as businesses interested in the management of renewable energy projects in Gauteng, South Africa. The study provided valuable insights and knowledge for companies that are considering venturing into the renewable energy sector in Gauteng, South Africa, as well as for those already involved in the sector.

The interviews with the management of organizations involved in renewable energy projects in South Africa could provide valuable first-hand insights into the management of such projects, including best practices, challenges, and opportunities. These insights could be valuable for other organizations considering similar projects in the future.

Overall, the target audience of this study seems to be management personnels in renewable energy projects in Gauteng, particularly businesses and organizations involved in the sector or considering entering the sector.

3.8.2 Sample and Sampling Framework

Sampling involves the process of selecting a subset from the complete set of elements that characterize the research phenomenon (Saunders et al., 2019). This subset, often referred to as a sample, allows for inferences to be drawn to address the research problem (Kumar, 2020). Essentially, a sample represents a portion or segment of the larger population. Creswell (2021:113) distinguishes between probability and non-probability sampling methods when conducting sampling.

Probability sampling is more suitable for statistical research and quantitative studies, while non-probability sampling is normative and non-statistical, making it appropriate for qualitative research (Kumar, 2020:147). The decision to employ non-probability sampling was based on its effectiveness in selecting knowledgeable and well-informed participants.

Non-probability sampling was specifically carried out using a purposive or judgmental sampling approach, which enabled the deliberate selection of key informants (Creswell, 2021:124). Purposive sampling allowed for the selection of individuals with expertise in renewable energy and knowledge management and demographic factors such as experience and position as determining criteria for their inclusion.

7.6.1. Criteria of the participants

According to Flick (2022:84), exclusion criteria are inclusion criteria but have features or characteristics that could negatively affect the outcome of the study. The key characteristics of inclusion criteria are those of the population that the researchers will use to answer the research questions. These are the criteria that were used for this investigation.

3.8.2.1 Inclusion criteria:

The criteria for selecting participants in a study on the knowledge management framework of renewable energy in Gauteng included:

- **Relevant expertise:** Participants had relevant expertise and experience in the management of renewable energy projects in South Africa. This included individuals who work for government agencies, independent power producers, energy companies, or academic institutions.
- **Position in the organization:** Participants held positions of authority or responsibility within their organizations, such as managers or executives, and be involved in decision-making related to renewable energy projects.
- **Project involvement:** Participants had been involved in the management of renewable energy projects in South Africa, either as project managers, team members, or other relevant roles.
- **Diversity:** Participants represented a diverse range of organizations, including government agencies, private companies, and non-governmental organizations, and have diverse backgrounds, such as engineers, and industry leaders.
- **Availability:** Participants were available and willing to participate in the study, which may involve interviews, surveys, or other forms of data collection.

Overall, the criteria for selecting participants should be based on the research objectives and methodology of the study and should aim to ensure that the participants have the necessary expertise and experience to provide valuable insights into the management information framework of renewable energy within the South African environment.

3.8.2.2 Exclusion criteria:

- **Geographical scope:** Given that the research question is focused on South Africa, studies that examine renewable energy management information frameworks in other countries or regions would be excluded.
- **Time frame:** To limit the review to studies published within a certain time frame, such as the last 10 years, in order to focus on current research and trends.
- **Language:** studies and human participant to that are uses other languages except English.
- **Relevance to topic:** studies that are not directly relevant to the topic.

3.8.3 Sample Size

Regarding sample size, Creswell (2021) defines it as the actual number of participants in the study. In line with qualitative research principles, where data saturation is a key consideration, a sample size of 8-20 participants is typically sufficient to reach data saturation (Kumar, 2020:148). Therefore, for this study, a sample of 10 participants was purposefully selected. This relatively smaller sample size is justified for several reasons:

- It ensures that data analysis can accommodate a reduced likelihood of eliciting new information from additional samples.
- Qualitative research is less concerned with prevalence or incidence rates.
- Qualitative research aims to obtain rich, in-depth findings. Considering these factors, a sample of 15 participants was purposefully chosen for the study due to its manageability and its capacity to yield rich data and achieve data saturation.

3.9 DATA COLLECTION PROCESS

The data collection is the process of eliciting views and perceptions from the selected sample regarding a particular research problem (Flick, 2022:176). The collection of data uses various techniques depending on which approach the study used. In the event the study is a qualitative research, observations, focus groups, interviews or documentary analysis can be used as data collection techniques. The data was collected using interviews in this research.

3.9.1 Interviews

An interview is a tool for gathering data that is often employed in qualitative research. It involves asking participants several questions about a particular subject and recording their responses. This information is valuable for gathering the key concepts and themes and formulating a hypothesis (Walliman., 2021:28). The interview that was used to collect the data for this study is coming from interviews that have already been conducted in the associated area of study. Even so, the interview was customized to best fit the information needed for this study. Utilizing previously conducted interviews was useful because they have been tried and tested and are recognized for their reliability and validity.

Compliance with the POPI Act (Protection of Personal Information Act) was part of the interviewing process. In order to prevent the misuse of personal information, the POPI Act's goal is to conduct research responsibly when collecting, storing, processing, and communicating personally identifiable information (Kumar, 2020). Everyone has the right to access any information kept by the government or any other person, but this right should not place an undue financial burden on the information holder (section 32(2)), which is what PAIA was designed to comply with (Van Wyk, 2019:25). All participant consent was obtained before collecting any data from them, and all information was protected throughout the whole data collection and analysis procedure for this study. In accordance with the PAIA, information will be available for participants to later recall their information until the date of destruction. The interviewing process followed the steps below:

3.9.1.1 Designing the measuring Instrument:

The interview guide was designed to collect the data for this study with questions developed from the research objectives. The interview guide was structured with open-ended questions. The interview was divided into two phases, the first of which will be used to collect the necessary demographic data and the second of which was used to collect the pertinent decision-making information.

3.9.1.2 Interview language

Interviews were conducted in English, as it was the primary language understood by the participants in their professional capacity. While English was not the first language for some participants, their high level of education and professionalism ensured their language proficiency. All participants were required to conduct interviews in English, eliminating the need for translation from their native languages. In most cases, participants expressed a preference for conducting interviews in English rather than their mother tongue.

3.9.1.3 Relationship between researchers and participants:

The conflict of interest between the researcher and the participating power generating plants is minimal to non-existent. The fact that the research is based on organisation outside of the researcher's organization reduces the likelihood of any bias or influence from the researcher's personal interests.

The only potential conflict of interest is that participants in in different power generating plants are direct competitors within the renewable energy sector. However, as long as the research is conducted objectively and without favouritism towards any particular organisation or IPP, this conflict of interest should not pose a significant concern.

To further mitigate any potential conflicts of interest, the researcher could disclose their relationship with the participating power generating plants and any financial interests they may have in the industry. This would help to ensure transparency and maintain the integrity of the research.

3.9.1.4 Scheduling of Interviews

Interviews were scheduled at the convenience of the participants and typically lasted between 30 to 60 minutes. While most participants allocated 60 minutes for interviews, some could only spare 30 to 40 minutes due to their busy schedules. Interviews were conducted using Teams given its allowance for recording of sessions for further analysis.

3.9.1.5 Interview Recording

Given that the interviews were conducted on Teams; video sessions were recorded. Participants were informed that recording interviews reduced distractions, such as note-taking, and allowed them to freely express their views. Semi-structured interviews were employed, providing flexibility and enabling the exploration of specific topics based on participants' responses. This approach encouraged participants to share their expertise, experiences, and stories.

Compliance with the POPI Act (Protection of Personal Information Act) was part of the interviewing process. In order to prevent the misuse of personal information, the POPI Act's goal is to conduct research responsibly when collecting, storing, processing, and communicating personally identifiable information (Walliman, 2020). Everyone has the right to access any information kept by the government or any other person, but this right should not place an undue financial burden on the information holder (section 32(2)), which is what PAIA was designed to comply with (Silverman, 2021). All participant consent was obtained before collecting any data from them, and all information was protected throughout the whole data collection and analysis procedure for this study. In accordance with the PAIA, information was available for participants to later recall their information until the date of destruction.

3.9.2 Rationale for Using Interviews

The semi-structured interview method, as described by Neuman (2017), guided the interviews. This approach involved customized questions, a strong interest in responses, open-ended questions, and a conversational style with interviewer guidance. The pace and direction of the interviews were jointly controlled by researchers and participants, adapting to participants' norms and language use.

The goal of the interview was to determine the strengths, weaknesses, and management knowledge framework for renewable energy in the environment of South Africa. The purpose of the interview was to determine the challenges, opportunities and strength of management knowledge framework of renewable energy in South Africa environment.

3.10 DATA ANALYSIS:

Data analysis is a technique that dissects a phenomenon into its constituent parts to enhance understanding. The primary aim of data analysis is to depict or present data assessments. In this study, thematic analysis was used as a data analysis technique.

3.10.1 Thematic Analysis

Thematic analysis, as advocated by Sekaran and Bougie (2019:78), serves as the chosen data analysis method. This thematic analysis will be executed using manual and theoretical means. Thematic analysis, a prevalent qualitative data analysis type, focuses on the identification and capture of meaningful data patterns (Creswell, 2021).

This approach enables data coding guided by research questions influenced by theoretical perspectives. Therefore, the utilization of theoretical thematic analysis to assess interview data is highly suitable for this research.

As outlined by Creswell (2021:182), it involves the following three steps:

1. The initial stage of inductive research involves using inductive techniques to become familiar with the interview data. It includes a thorough review of the reported data for accuracy and familiarity. This inductive phase emphasizes not only the details of the data but also considers transcripts and recurring comments (Field *et al*, 2012:34).
2. The induction process in the second stage delves into comprehensive transcript reading and comments in addition to ensuring data accuracy.
3. Researchers can further categorize knowledge by using codes and developing themes, as well as organizing essays and transcripts. This approach aligns with the explanatory nature of this research (DeJonckheere & Vaughn, 2019:7).

3.11 QUALITATIVE RESEARCH RIGOUR AND VALIDITY

In qualitative research, trustworthiness relates to establishing positive reliability and validity (Saunders *et al.*, 2019). To ensure the authenticity and trustworthiness of this research, the qualitative research process, detailing what was done, how, and why, adheres to recognized qualitative research standards. According to Creswell (2021:38), the rigor of the qualitative component is linked to the overall planning and implementation, emphasizing authenticity and trustworthiness through specific procedures:

3.11.1 Consistency or Dependability

Dependability in qualitative research is akin to the concept of reliability in quantitative research, as it signifies that another researcher following the same research plan would achieve similar outcomes (Kumar, 2020). This research adheres to a well-defined research design process, encompassing inductive research techniques, descriptive research objectives, explanatory perspectives, and case research strategies, as previously outlined. It was not conducted randomly but followed Saunders *et al.* (2019:198)'s Research Onion model, ensuring realistic and dependable aspects of the research methodology.

3.11.2 Transferability or Applicability

Transferability, akin to external validity in quantitative terms, examines whether the research findings can be applied to different contexts (Noble & Heale, 2019:67). Data collection methods and other research techniques have been meticulously examined and justified. The transferability approach of this study, following Saunders *et al.*, (2019:31), treats population, data collection, and samples as transferability challenges. Due to the similarities and contextual relevance, the research results are transferable to other South African organisation with similar characteristics.

3.11.3 Credibility

Credibility, similar to internal validity in quantitative studies, pertains to testing and ensuring the accuracy of results (Creswell, 2021:34). The use of triangulation and the formal interpretation of research tools are means of checking and enhancing the

credibility of research design and implementation. The study incorporated additional data collected through interviews and report reviews intensively. Triangulating the theoretical framework and related models with diverse data sets has bolstered the credibility of this research.

3.11.4 Confirmability

Once integrity, transferability, and reliability have been established, confirmability follows. Confirmability measures the extent to which researchers' ideas influence research outcomes, aiming to ensure that participants' contributions outweigh researchers' biases, as explained by Flick (2022:163). This research enhances confirmability by deriving core themes and related topics from the entire data collection process, relying on the views and experiences of participants rather than those of the researchers.

3.12 ETHICAL CONSIDERATIONS

3.12.1 Ethical Issues:

The participating businesses was maintained confidential and just mention the type of renewable power generation plant within the sector that will be participating, allowing for non-intrusive analysis of the data gathered through interviews. The strict ethical requirements for the research study were conveyed to potential participants, and any observations were kept private. The informed consent letter, which also states that the research proposal was subjected to the ethical clearance process of the Faculty of Economic and Management Sciences Ethics Committee. The ethical clearance was approved and the ethical clearance number is: [N W U – 0 1 8 8 0 – 2 3 – A 4].

To preserve anonymity, the researcher had complete control over both the conduct of the interviews and the analysis of the information gathered from interviews. The researcher shall always guarantee that all information is kept secure, referring to the POPI Act to protect data from theft and prejudice.

3.12.2 Informed Consent:

In assisting the researcher and other organizations in need of similar studied knowledge, the study's goal was to do research on the suggested issue. To ensure

ethical behaviour, all ethical considerations were outlined prior to conducting the interview. The interviews will be kept until demolition takes place, and anonymity was protected by analysing the data received from the interview without disclosing any obtained organization or personal information.

The participants were made aware of the study's objectives and the fact that the Business School of the North-West University used the collected data for research project and publications before the study even begins. Participants were informed that their participation is entirely optional and that they may opt-out at any moment up until the research project's due date. The interview lasted approximately 15 to 20 minutes, and it was recorded for documentation. There was, regrettably, be no other rewards outside access to the completed research article.

3.13 LIMITATIONS OF THE STUDY:

While the study made important contributions to the field of renewable energy management in South Africa, there were also some limitations that should be considered. These limitations include:

Small sample size: The study used a qualitative research approach, and the data was collected through in-depth interviews with only 10 renewable energy experts and managers. This small sample size may limit the generalizability of the study's findings.

Limited scope: The study focused only on the management knowledge framework of renewable energy in the South African environment. Other factors that may influence the successful implementation and management of renewable energy projects, such as social and environmental factors, were not considered.

Potential for bias: The study relied on the perspectives of renewable energy experts and managers, which may not represent the views of all stakeholders in the South African renewable energy sector. Additionally, there may be biases in the selection of interviewees and the interpretation of their responses.

Lack of quantitative data: The study relied solely on qualitative data, which may limit the ability to make precise and accurate conclusions about the management knowledge framework of renewable energy in South Africa.

Lastly the issue of fast technological developments and this being a study of technology, the study will only be accurate until the data will be gathered.

In this case, being a student there are common limitations of available resources and time. Resources are quite low, and the time is very much constrained.

Overall, while the study provided valuable insights into the management knowledge framework of renewable energy in South Africa, its limitations should be considered when interpreting the findings.

3.14 EMPIRICAL RESEARCH FINDINGS PRESENTATION

The main purpose of this section is to summarize the research results. This section is used to provide information about response rates, demographics, and study results.

3.14.1 Demographic details

Demographic data plays a vital role in research surveys. As Walliman (2020) highlights, these details provide valuable insights into survey participants and their role in representing the broader target population. In essence, demographics help in understanding the characteristics of the target population and their relevance in solving the research problem. The demographics presentation was deduced from a sample of 10 participants who consented to participate while five (5) turned down invitation to the study. Therefore, the study collected subsequent demographic information from participants:

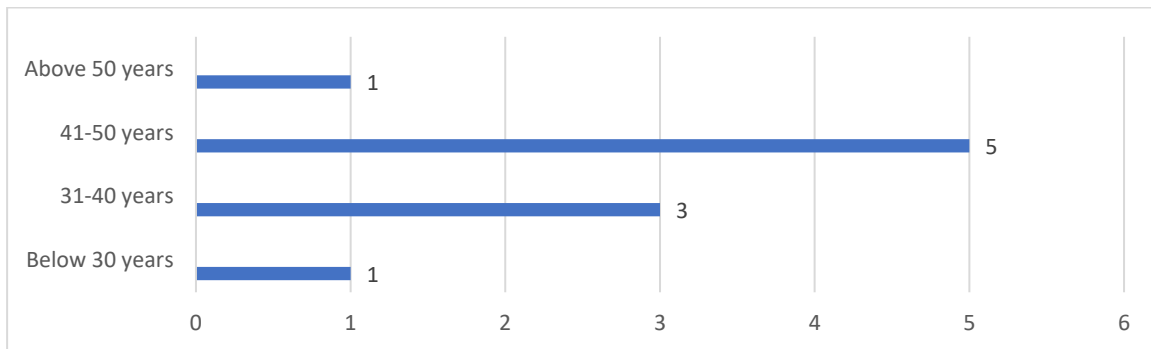
- Position in the organisation
- Duration of Service in Current Position
- Age Group Composition

3.14.1.1 Age Group Composition

An important aspect of demographic data is the age distribution of the research subjects, which may be understood from the age distribution of the participants. Furthermore, age may occasionally influence participants' perceptions of the research

phenomena or the topic under investigation. Figure 3.22 shows the ages of the participants in the following manner:

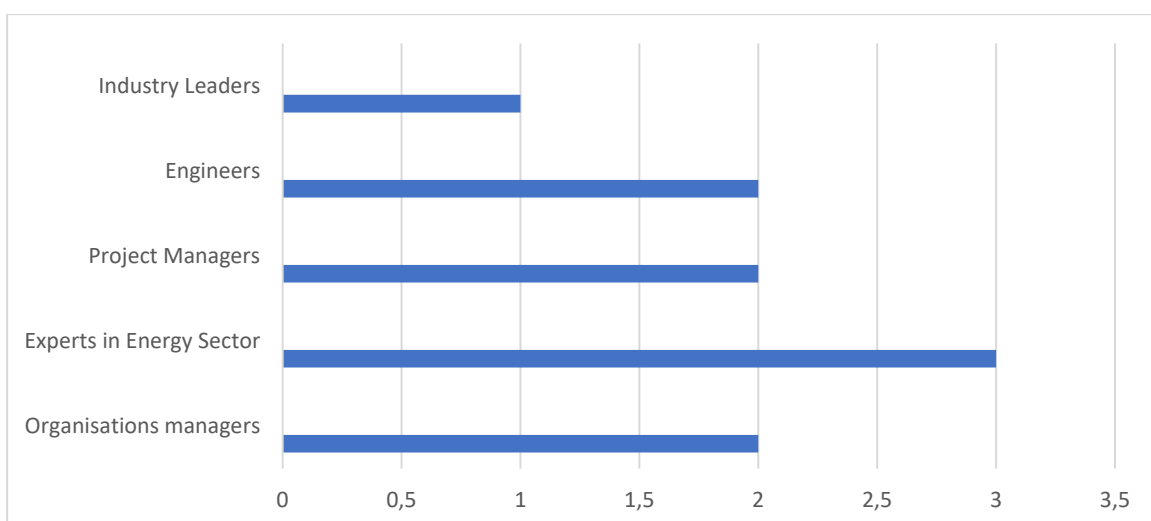
Figure 3.2: Age Group Composition of the Participants



3.14.1.2 Position in the organisation

Understanding participants' positions within the organization can help researchers assess how different roles influence their responses and insights, thereby adding depth to the findings. The importance of “position in organization” among the demographic details lies in its role as a key identifier of the participant's professional roles and responsibilities. The positions compositions of the participants are illustrated in Figure 3.3 below:

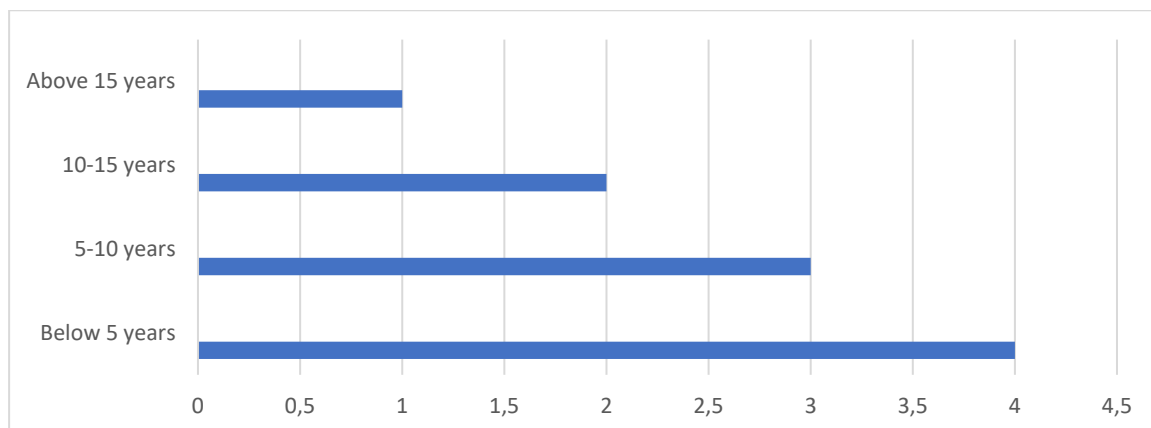
Figure 3.3: Position in the organisation



3.14.1.3 Duration of Service in Current Position

The length of service in current position is an important demographic detail because it provides insight into the participant's experience level and tenure in their current position. Figure 3.4 shows the distribution of the composition of participants:

Figure 3.4: Duration of Service in Current Position



3.14.2 Presentation of findings

The results are structured in alignment with the research tool, and Section B specifically deals with inquiries related to the research query. Each participant's individual responses to the questions are presented. Subsequently, responses were grouped based on recurring themes and argumentative patterns. To uphold ethical considerations, participants have been assigned code names from Participant 1 to Participant 10.

3.14.2.1 Section B: Knowledge Management Practices and best practices

What specific knowledge management strategies and practices have you observed in the renewable energy sector, and how do these contribute to innovation and collaboration among sector stakeholders?

The study asked about specific knowledge management strategies and practices observed in the renewable energy sector and how they facilitate innovation and collaboration among sector stakeholders. Detailed responses are summarized below:

Participant 1: Many organizations in the renewable energy sector have established internal and external knowledge sharing platforms, including intranet portals, wikis and online forums, where employees and sector stakeholders can share information, research results, best practice and lessons learned.

Participant 2: Organizations, research institutions, and government agencies often work together through collaboration, research, and development to advance technology and develop innovative solutions. These collaborations facilitate the sharing of research results, leading to the creation of collective knowledge.

Participant 3: Renewable energy organizations collect large amounts of data, such as weather data, energy production statistics and grid performance data, from a variety of sources including sensors and monitoring systems. Sharing data and analytical tools fosters collaboration and innovation.

Participant 4: Many conferences and seminars are held in the field of renewable energy, where experts and professionals from different backgrounds come together to discuss the latest developments.

Participant 5: Government agencies often play a vital role in the renewable energy sector by funding research and development projects and setting standards and regulations.

Participant 6: Educational institutions offer programs and courses focused on renewable energy technologies. These programs not only educate the future workforce but also serve as centers for knowledge creation and dissemination.

Participant 7: Sector associations and consortia such as the Solar Energy Industries Association (SEIA) and the American Wind Energy Association (AWEA) promote collaboration between companies and advocate for sector interests.

Participant 8: Some organizations in the renewable energy sector adopt open innovation principles and actively seek ideas and solutions from external sources, including the public.

Participant 9: Sharing knowledge and research results fosters a culture of innovation and enables sector stakeholders to learn from each other, thereby accelerating technological progress.

Participant 10: Industry-wide collaboration and knowledge sharing can promote the development of standardized practices and technologies, making it easier for stakeholders to collaborate and integrate renewable energy systems.

In your experience, how has knowledge management impact on the effective adoption and operation of renewable energy technologies?

Knowledge management plays a vital role in the effective adoption and operation of renewable energy technologies. In response, the study asked participants about the impact of knowledge management on the effective adoption and operation of renewable energy technologies.

Participant 1: Effective knowledge management helps transfer the knowledge and expertise of experienced individuals to those new to the renewable energy sector.

Participant 2: Knowledge management helps identify and disseminate best practices in the design, installation, operation and maintenance of renewable energy technologies. These best practices reduce the possibility of errors and ensure optimal system performance.

Participant 3: Through feedback loops and sharing lessons learned, knowledge management supports a culture of continuous improvement as they learn from past experiences, identify and correct problems to improve the performance and reliability of renewable energy systems.

Participant 4: Knowledge management creates an environment where research, innovation and emerging technologies are shared across the industry.

Participant 5: Access to a maintenance and troubleshooting knowledge base helps operators resolve problems faster and more efficiently. This reduces downtime and minimizes maintenance costs, thereby enhancing the economic viability of renewable energy projects.

Participant 6: Effective knowledge management ensures that security guidelines and regulatory compliance requirements are fully understood and consistently followed. This is essential to protect workers and the environment, as well as avoid legal and financial risks.

Participant 7: Knowledge management extends to data management and analysis. Proper data collection, storage and analysis practices are critical to optimizing the performance of renewable energy systems.

Participant 8: Knowledge management encourages collaboration between different disciplines, including engineering, environmental science and policy development. This interdisciplinary collaboration is critical to solving the complex challenges associated with renewable energy adoption and operation.

Participant 9: Effective knowledge management enables sector stakeholders to collect and share data, research and insights that can influence renewable energy policy and regulations.

Participant 10: Knowledge management can be extended to public awareness and education campaigns. Educating the public about renewable energy technologies, their benefits and their effective use is critical to encourage wider adoption.

Can you explain how shared knowledge has been instrumental in addressing interconnected challenges and fostering sustainable development in the industry?

The shared knowledge plays a key role in addressing interrelated challenges and promoting sustainable development in various industries, including the renewable energy industry. Attendees were asked to explain how shared knowledge can help solve interrelated challenges and promote sustainable development in the industry.

Participant 1: Shared knowledge enables sector stakeholders to work together to address complex and interconnected challenges. Renewable energy is about more than just generating clean electricity; it's about grid integration, energy storage, mitigating environmental impacts, and more.

Participant 2: Shared knowledge enables these different sectors to work together effectively, leveraging each other's expertise to solve interconnected challenges such as reducing carbon emissions, increasing energy efficiency and minimizing environmental impact.

Participant 3: Policymakers rely on shared knowledge to develop effective regulations and incentives to support the growth of renewable energy. This knowledge is derived from a wide range of sources, including sector research, expert opinion and public feedback.

Participant 4: Renewable energy projects often involve significant investments and come with inherent risks. By sharing knowledge about project finance, risk assessment and insurance, sector stakeholders can work together to minimize financial and operational risks.

Participant 5: Sharing knowledge helps educate the public, business and policymakers about the benefits and challenges of renewable energy.

Participant 6: Shared knowledge enables technology transfer and capacity building, allowing less experienced regions to benefit from the expertise of others and accelerate their renewable energy deployment.

Participant 7: Sharing knowledge helps ensure comprehensive impact assessments, enabling responsible project development and reducing negative impacts on ecosystems and communities.

Participant 8: Collaborative research and data-sharing initiatives help better understand the environmental, economic and social impacts of renewable energy projects. Shared knowledge helps identify potential problems and implement corrective measures to promote sustainability.

Participant 9: Shared knowledge can accelerate market growth and sector expansion by providing insights into market trends, consumer preferences, and emerging technologies. This information enables companies to make informed decisions and effectively allocate resources to meet the growing demand for renewable energy solutions.

Participant 10: In the renewable energy sector, interconnected challenges are often shared across the globe. International cooperation and knowledge exchange enable countries and regions to learn from each other's experiences, share successful strategies and work together to achieve global sustainable development goals.

3.14.2.2 Section C: Key Barriers and Facilitators that Impact the Effectiveness of Knowledge Management

What are the key technical and technological challenges facing the expansion of renewable energy in South Africa, and how are they being addressed?

The study asked participants about the key technical challenges facing the expansion of renewable energy in South Africa and how they might be addressed. The details of the reply are as follows:

Participant 1: The intermittency of renewable energy sources such as solar and wind can put stress on the grid, leading to reliability issues and grid stability challenges.

Participant 2: South Africa is investing in grid upgrades and energy storage solutions, such as battery storage and pumped hydro, to manage variable renewable energy generation and improve grid reliability.

Participant 3: Inadequate energy storage infrastructure hampers the ability to store excess energy during peak renewable generation periods and release it when needed.

Participant 4: Steps are being taken to develop energy storage projects, including utility-scale battery installations, to balance the grid and better integrate renewable energy.

Participant 5: Access to finance for renewable energy projects, especially small-scale and community-based projects, is a challenge.

Participant 6: The South African government, along with international organizations and investors, is working to provide financial support, incentives and loan guarantees to stimulate investment in renewable energy projects.

Participant 7: South Africa's transmission and distribution infrastructure needs to be expanded and modernized to accommodate growth in renewable energy capacity.

Participant 8: Continued investment in upgrading transmission and distribution networks and developing renewable energy corridors to increase infrastructure capacity.

Participant 9: A skilled workforce is critical to the construction, operation and maintenance of renewable energy projects. Governments, educational institutions and sector partners are collaborating on training and capacity-building programs to develop a skilled workforce to support the renewable energy industry.

Participant 10: Policy and regulatory frameworks need to be clear, consistent and supportive of renewable energy development. South Africa has been committed to providing a stable and transparent regulatory framework, including feed-in tariffs and power purchase agreements, to attract investment and create an enabling environment for renewable energy projects.

What, in your experience, have been the primary barriers to effective knowledge management in the renewable energy sector in South Africa, and how have these obstacles impacted the industry's progress?

The study asked participants about the main barriers to effective knowledge management in South Africa's renewable energy sector and how these barriers impact progress in the industry.

Participant 1: Inadequate data collection, storage and sharing mechanisms hinder the availability of comprehensive and up-to-date information. This makes it difficult for stakeholders to make informed decisions, conduct in-depth research, and make accurate assessments of renewable energy potential and performance.

Participant 2: Limited funding and investment in R&D activities reduces the development of innovative renewable energy technologies and solutions. The sector struggles to stay at the forefront of technological advancements, resulting in slow progress in reducing costs and improving efficiency.

Participant 3: Skill shortages and limited training opportunities in the renewable energy workforce are hampering the industry's growth. This has resulted in a shortage of qualified personnel to design, install, operate and maintain renewable energy projects, affecting project quality and reliability.

Participant 4: Regulatory and policy uncertainty, including changing feed-in tariffs and grid integration regulations, creates challenges for long-term planning and investment. These uncertainties are discouraging investors and slowing the development of renewable energy projects.

Participant 5: The lack of a centralized, accessible knowledge-sharing platform hinders the exchange of best practices, lessons learned, and sector expertise. The sector misses out on opportunities for collective learning, and projects often have to reinvent solutions that have been developed elsewhere.

Participant 6: High upfront costs and limited financing options create financial barriers to project development. Many promising renewable energy projects remain unrealized due to an inability to secure sufficient funding, hampering sector growth.

Participant 7: Coordinated efforts are hampered by limited collaboration and communication among various stakeholders, including government agencies, private sector companies and research institutions. The sector misses out on synergies that could accelerate progress, such as shared research programs or joint investments in infrastructure.

Participant 8: Challenges related to land use and grid connection permits complicate project development and grid connection. Delays in obtaining permits and grid connection hinder the timely deployment of renewable energy projects.

Participant 9: Public concerns about the environmental and social impacts of renewable energy projects have led to boycotts and opposition. Opposition from local communities and environmental groups slowed project development and created negative public perception.

Participant 10: A lack of sector standards and guidance for renewable energy technologies and practices hinders quality consistency and interoperability. It leads to inefficiencies, higher costs, and limits the scalability of renewable energy solutions

In what ways do the key barriers manifest in the renewable energy innovation and operations?

Key barriers to effective knowledge management in the renewable energy sector can manifest themselves in a number of ways, affecting innovation and day-to-day operations within the industry. Participants were asked what the main barriers are to renewable energy innovation and operations.

Participant 1: Insufficient data can lead to poor decision-making, particularly in project siting and resource assessment. Without accurate and up-to-date information, renewable energy projects can become less efficient and reliable, resulting in suboptimal operations.

Participant 2: Insufficient investment in R&D can lead to stagnant technological development. Without innovative solutions, the sector may struggle to reduce costs and improve the performance of renewable energy systems, hindering the advancement of new technologies.

Participant 3: A lack of skilled personnel can lead to poor project execution. Insufficient training and knowledge transfer can lead to suboptimal maintenance and operating practices, reducing the overall efficiency and reliability of renewable energy systems.

Participant 4: Frequent changes in regulations and policies can create uncertainty for investors and project developers. This can lead to project delays, cost overruns and a reluctance to invest in renewable energy, impacting innovation and operational stability.

Participant 5: Without an effective knowledge-sharing platform, organizations can struggle to capture best practices and lessons learned from other projects. This can lead to repeated errors and missed opportunities to improve efficiency.

Participant 6: High upfront costs and limited financing options can prevent projects from reaching the planning stage. This could lead to a lack of innovation and reduced renewable energy generation capacity.

Participant 7: Limited collaboration and communication among stakeholders can lead to fragmented efforts. This can lead to a lack of alignment on shared goals, slow the pace of innovation and delay project development and implementation.

Participant 8: Challenges related to land use and grid access can lead to project delays and increased development costs. These issues can slow down the deployment of renewable energy projects and hinder operational progress.

Participant 9: Opposition from local communities and environmental groups could lead to project cancellations or delays. These challenges can create negative public perceptions and impact social license to operate, thereby impacting innovation and operations.

Participant 10: The lack of sector standards can lead to inefficiencies and interoperability issues. This can result in renewable energy solutions that are costlier, less reliable, and lack scalability.

3.14.2.3 Section D: Current state of renewable energy in South Africa

What is the current status of renewable energy management in South Africa and what are the future prospects?

The participants were asked about the current state of renewable energy in South Africa. The responses are detailed below:

Participant 1: South Africa's REIPPP scheme has successfully attracted private sector investment and expertise to procure significant amounts of renewable energy capacity. In particular, solar and wind energy projects have been developed and contributed to the country's electricity generation.

Participant 2: Several renewable energy projects, including solar photovoltaics (PV) and wind farms, are already operational and contributing to the national grid. These

projects help diversify the energy mix and reduce the country's dependence on fossil fuels.

Participant 3: South Africa has been exploring energy storage solutions, including utility-scale battery storage, to address the intermittency of renewable energy and enhance grid stability. This effort is designed to maximize the benefits of renewable energy.

Participant 4: Capacity building programs and educational initiatives are ongoing to develop a skilled workforce capable of operating and maintaining renewable energy facilities.

Participant 5: Progress has been made in the integration of renewable energy into the grid, and the integration of renewable energy into the grid has become smoother.

Participant 6: South Africa is likely to continue expanding renewable energy capacity, including wind, solar and biomass. The country has set ambitious renewable energy targets as part of its Integrated Resource Plan (IRP), aiming to further diversify its energy mix.

Participant 7: The adoption of energy storage solutions is expected to increase, improving grid reliability and stability while allowing for greater integration of variable renewable energy sources.

Participant 8: South Africa is likely to benefit from continued technological advances in renewable energy, leading to greater efficiencies and lower costs, which will make renewables more competitive.

Participant 9: South Africa's renewable energy sector is expected to grow at both regional and local levels. Smaller-scale renewable energy projects, including community-owned facilities, may play a more important role.

Participant 10: Investments in grid upgrades and infrastructure enhancements are critical to ensuring efficient grid integration and successful management of renewable energy.

How have the policies and initiatives, such as the Renewable Energy Independent Power Producer Procurement (REIPPP) program, influenced the growth and development of renewable energy projects in South Africa?

These policies and initiatives, including the Renewable Energy Independent Power Producer Procurement (REIPPP) scheme, have had a significant impact on the growth and development of renewable energy projects in South Africa. In this regard, participants were asked how policies and initiatives such as the Renewable Energy Independent Power Producer Procurement (REIPPP) scheme impact the growth and development of renewable energy projects in South Africa.

Participant 1: The REIPPP scheme has been particularly successful in attracting private sector investment in renewable energy projects. Independent power producers (IPPs) are selected through a competitive bidding process to develop and operate renewable energy facilities. This private investment injects capital into the sector and promotes the development of renewable energy capacity.

Participant 2: These policies and initiatives have played a crucial role in diversifying South Africa's energy mix. The introduction of renewable energy sources such as wind and solar energy reduces this dependence and contributes to a cleaner and more sustainable energy mix.

Participant 3: These plans have resulted in a significant increase in renewable energy capacity in South Africa. This growth not only helps meet the country's electricity needs but also lays the foundation for further expansion of the industry.

Participant 4: The REIPPP scheme's competitive bidding process drives technological advancement and innovation in renewable energy projects. Developers are encouraged to find more efficient and cost-effective ways to generate electricity from renewable energy sources.

Participant 5: These policies and initiatives create jobs and skills development in the renewable energy sector. The construction, operation and maintenance of renewable energy projects creates jobs and promotes the development of a skilled workforce.

Participant 6: The growth of renewable energy projects has led to improved grid integration. Grid management and stability are becoming more complex to accommodate intermittent renewable energy sources and improve the reliability of the national grid.

Participant 7: These policies and initiatives emphasize the importance of sustainable development and mitigating environmental impacts. They encourage renewable energy projects to incorporate environmental and social sustainability measures to achieve positive results in terms of emissions reduction and community engagement.

Participant 8: Transparent procurement processes and the establishment of long-term power purchase agreements (PPAs) have enhanced investor confidence in the industry. This makes it more attractive for local and international investors to participate in renewable energy projects in South Africa.

Participant 9: These initiatives are not limited to utility-scale projects. They also promote small-scale renewable energy projects and community engagement, promoting regional and local development and energy independence.

Participant 10: Government Commitment to Renewable Energy: The Government's support for these policies and initiatives underscores its commitment to renewable energy as a key component of the nation's energy future.

Given the increasing contribution of renewable energy to South Africa's electricity generation, what measures are in place to ensure the sector's long-term sustainability and success?

To ensure the long-term sustainability and success of South Africa's renewable energy industry, South Africa has developed a series of policies, strategies and initiatives. These measures are designed to address various challenges and promote the continued growth and viability of renewable energy in the country. The study therefore asked participants what measures were being taken to ensure the long-term sustainability and success of the sector, given the increasing contribution of renewable energy to South Africa's electricity generation.

Participant 1: South Africa's Integrated Resource Plan is an important policy document that outlines the country's energy mix and generation targets. The IRP includes plans to increase renewable energy capacity over the long term, providing a clear roadmap for sustainable growth.

Participant 2: The REIPPP scheme remains the core mechanism for procuring renewable energy projects. It involves competitive bidding and long-term power purchase agreements (PPAs) to ensure the stable development of renewable energy projects and attract private sector investment.

Participant 3: South Africa has committed to more rounds of competitive tendering under the REIPPP scheme to encourage the development of new renewable energy projects and foster cost-competitive solutions.

Participant 4: Investments in grid infrastructure and energy storage solutions, such as battery storage and pumped hydro, are underway to enhance grid stability and accommodate the variability of renewable energy.

Participant 5: Governments, research institutions and sector stakeholders collaborate on R&D activities to drive technological advancement, increase the efficiency of renewable energy systems and reduce costs.

Participant 6: Capacity-building programs and educational initiatives are in place to develop a skilled workforce capable of operating and maintaining renewable energy facilities, ensuring the long-term sustainability of the industry.

Participant 7: Sustainability principles are incorporated into renewable energy projects to minimize environmental and social impacts. Environmental impact assessments and community engagement efforts help ensure the industry's continued acceptance and success.

Participant 8: South Africa aims to provide regulatory and policy stability and create an enabling environment for renewable energy projects. Transparent procurement processes, stable feed-in tariffs and consistent grid integration rules are critical for investor confidence.

Participant 9: Promoting small-scale renewable energy projects and community ownership initiatives can boost regional and local development, contribute to energy independence, and align with wider sustainable development goals.

Participant 10: South Africa works with international partners, organizations and funding agencies on renewable energy projects and initiatives, leveraging global expertise and resources to advance the sector.

3.14.2.4 Section E: Integration of an Improved Knowledge Management Framework Within the Renewable Energy

What are some key project-specific risks faced by renewable energy projects in South Africa, and how have they been mitigated to ensure project resilience and success?

As in many other countries, renewable energy projects in South Africa face a variety of project-specific risks that can impact their success and resilience. To ensure the feasibility of the project and mitigate these risks, a variety of strategies and measures were implemented. In this regard, participants were asked about the key project-specific risks faced by renewable energy projects in South Africa and how these risks can be mitigated to ensure project resilience and success. The responses obtained are summarized below:

Participant 1: Delays or difficulties in connecting renewable energy projects to the national grid could impact project timelines and revenues. South Africa has invested in grid infrastructure and established clear grid connection rules to ensure timely connection. Developers need to meet grid code requirements to enhance grid stability.

Participant 2: Renewable energy projects such as wind and solar rely on variable resources. Inaccurate resource assessments can lead to poor performance. Employ detailed resource assessments and advanced weather forecasting techniques to increase resource predictability and maximize project performance.

Participant 3: Opposition from local communities or environmental groups can lead to project delays or cancellations.

Participant 4: Conduct a comprehensive environmental impact assessment, community engagement and stakeholder consultation to address issues and build local support for the project. Projects may also include measures for habitat restoration and wildlife conservation.

Participant 5: Currency exchange rate fluctuations, interest rate changes and revenue uncertainty can pose financial risks to renewable energy projects. Use long-term power purchase agreements (PPAs) with fixed electricity prices, currency hedging and transparent project financing to reduce financial uncertainty and attract investors.

Participant 6: Difficulties in obtaining land rights and permits for renewable energy projects can lead to project delays and increased costs. Responsible land use planning, early engagement with relevant authorities, and compliance with permitting requirements can help streamline the process and reduce potential barriers.

Participant 7: Technical issues and equipment failures can impact project performance and revenue. Reduce technical risks and ensure smooth operations through regular maintenance, performance monitoring, and the use of high-quality equipment and technology.

Participant 8: Market fluctuations, changes in energy demand and policy uncertainty can all affect project economics. Diversified energy mix, long-term power purchase agreements and government-supported renewable energy policies help stabilize project revenue and reduce market risks.

Participant 9: Inaccurate resource assessments can lead to overestimation of energy production and poor performance. Improved resource assessment methods, advanced modeling and data collection techniques help increase the accuracy of resource assessments and reduce uncertainty.

Participant 10: Changes in laws and regulations may affect the viability and profitability of projects. South Africa aims to provide regulatory stability and transparency and create an enabling environment for renewable energy projects. Stable feed-in tariffs and transparent procurement processes help reduce legal and regulatory risks.

How have policies like feed-in tariffs, renewable energy targets, and tax incentives created a favorable environment for technology adoption in South Africa's renewable energy industry, and what measures are in place to ensure policy stability and consistency?

Policies such as feed-in tariffs, renewable energy targets and tax incentives have played a vital role in creating an enabling environment for technology adoption in South Africa's renewable energy industry. These policies attract investment, accelerate technology adoption, and promote sector growth. Several measures were taken to ensure policy stability and consistency. Details of the responses obtained are as follows:

Participant 1: Feed-in tariffs guarantee fixed payments to renewable energy producers, making it financially attractive for developers to invest in renewable energy projects. This policy particularly incentivizes the adoption of solar and wind energy technologies.

Participant 2: To ensure policy stability, South Africa has moved away from feed-in tariffs to competitive bidding processes such as the Renewable Energy Independent Power Producer Procurement (REIPPP) scheme. Competitive auctions provide transparency, allow for price discovery, and reduce the need for fixed feed-in tariffs.

Participant 3: The Renewable Energy Target provides a clear roadmap for the industry, demonstrating the Government's commitment to adopting clean energy. These goals drive investment in a variety of renewable technologies, including wind, solar and biomass.

Participant 4: Tax benefits such as accelerated depreciation and tax credits can ease the financial burden of investing in renewable energy. They encourage businesses and investors to adopt clean energy technologies.

Participant 5: South Africa has developed a tax incentive scheme for renewable energy projects and incorporated these incentives into relevant tax legislation, creating a stable and consistent framework for technology adoption.

Participant 6: A clear and transparent regulatory framework is critical for technology adoption. It provides developers with the legal and financial certainty they need to invest in renewable energy projects.

Participant 7: South Africa has been working to provide a stable regulatory framework through long-term power purchase agreements (PPAs) and grid integration rules to facilitate technology adoption and grid connectivity.

Participant 8: Diverse markets including onshore and offshore wind, solar photovoltaics, concentrated solar power (CSP) and biomass encourage technological diversity and innovation.

Participant 9: South Africa's procurement plans and diversified renewable energy portfolio create stable markets for a variety of technologies, reducing reliance on a single technology type.

Participant 10: The South African government works with sector representatives and other stakeholders to ensure that policies and regulations are balanced and meet the needs of all interested parties.

Could you discuss ongoing efforts and initiatives to accelerate technology innovation in the South African renewable energy sector and the role of research and development in this process?

The South African renewables industry's ongoing efforts and initiatives to accelerate technological innovation are critical to driving the development of cutting-edge solutions and ensuring the long-term sustainability of the industry. Against this backdrop, participants were asked about their views on ongoing efforts and initiatives in South Africa's renewable energy sector to accelerate technological innovation and the role of R&D in this process.

Participant 1: South Africa encourages collaboration between the public and private sectors to promote technological innovation. Joint ventures and partnerships between government agencies, research institutions and sector stakeholders are critical to R&D initiatives.

Participant 2: Various research institutions and universities in South Africa are actively engaged in renewable energy R&D. These institutions conduct research in resource assessment, technology development and energy system modeling to drive innovation.

Participant 3: Solar innovation is the focus. Research and development efforts are aimed at improving solar photovoltaic (PV) technology, including the development of advanced photovoltaic materials, high-efficiency solar panels and integrated photovoltaic systems.

Participant 4: Wind energy research focuses on improving the efficiency of wind turbines and exploring innovative designs. Advanced materials, blade design and wind farm optimization are key areas of interest.

Participant 5: Developing energy storage technologies such as advanced battery systems and grid-scale energy storage is a top priority. Efficient energy storage is critical to managing the intermittency of renewable energy sources.

Participant 6: Research and development is dedicated to improving grid integration solutions, including developing smart grid technologies, demand response systems and grid control strategies to improve the reliability of renewable energy integration.

Participant 7: The government supports technology demonstration and pilot projects to test and demonstrate innovative renewable energy solutions. These initiatives often receive financial incentives and grants.

Participant 8: Various incentives, such as research grants and tax incentives, can stimulate innovation in the renewable energy sector. These incentives encourage companies and researchers to invest in R&D.

Participant 9: South Africa places emphasis on developing a skilled workforce with expertise in renewable energy technologies. Education and training programs provide the skills needed to support innovation and technology adoption.

Participant 10: South Africa collaborates with international partners, organizations and research institutions on joint research projects and technology exchange programmes. These collaborations help leverage global expertise and resources.

3.15 CONCLUSION

The chapter deliberated the research design and methodology used in the primary study. The chapter covered the research design, research philosophy, sampling, data collection, and data analysis. The same chapter deliberated the pilot study, the trustworthiness of the study, the elimination of bias, and the limitations of the study. The thrust was to outline how the significance explore knowledge management framework for renewable energy in South Africa.

The next chapter thereby discusses, interprets, and analyse the research findings addressing the research objectives and the research problem.

CHAPTER 4: CONCLUSIONS AND RECOMMENTATIONS

4.1 Introduction

The previous chapter mainly focused on explaining the study approach and providing the findings about the assessment and enhancing of the knowledge management framework within the renewable energy sector in South Africa. However, in this chapter, the focus is more on an analysis of the results, on making recommendations, and on drawing conclusions. The study commences by examining the demographic findings from the study is how the chapter begins. The study findings are then carefully examined, which leads to the presentation of suggestions and conclusions in the end.

4.2 Discussion of demographic results

The discussion in this section refers to section A of the interview list. The section discusses the demographic results from the study.

4.2.1 Position in the Organization

The study covered the participants in various positions in the organisation. In this regard, position in the organization refers to the job title or role that an individual occupies within a given organization. The study had a majority of three (3) from the experts in energy sector, two (2) renewable energy organisational managers, two (2) renewable energy project managers, two (2) engineers and one (1) sector leader. According to Creswell (2018), the position of the participant in the organisation is vital as it can provide valuable information about the hierarchy and structure of the workforce. It may include details on job levels, such as executive, manager, or staff positions, and can be used to assess the distribution of leadership roles, responsibilities, and decision-making authority within the organization is as far as renewable energy is concerned.

4.2.2 Age Group Composition

The age group composition of the participants allowed the participants to consult individuals of various ages. This stems from Kumar (2020)'s deliberation that age can be a contributory factor towards participant's perception. In the study, the majority of

participants were in the 41-50 years of age, three (3) participants were in 31-40 years, one (1) was in the below 30 years and one (1) in the above 50 years of age. Against such a background, it is sufficing to state that the study synthesizes various perspectives from different age groups. As propounded by Creswell (2018), different age groups bring unique understandings and interpretations of any subject or issues at hand within a research.

4.2.3 Duration of Service in Current Position

The study unveiled the participants' diverse work backgrounds, enabling the extraction of conclusions from the extensive array of experiences they contributed to the research. In this context, four participants had below five years of experience, three participants possessed 10-15 years of experience, four participants had 5-10 years of experience, and one participants had above 15 years of experience. The work experience data collected during the study underscores the deliberate and purposeful approach to data collection. However, Kumar (2020) articulated that participants with substantial work experience within a specific field or sector often harbor valuable expertise and profound knowledge pertinent to the study. Consequently, this expertise results in more astute and insightful responses regarding the enhancing of the knowledge management framework within the renewable energy sector in South Africa.

4.3 Discussion of findings

As outlined by Saunders et al. (2019), qualitative data analysis can be perceived as a method encompassing the integration of data, imparting purpose to the data, structuring it, and assigning significance to the data concerning the research project. Data analysis assumes a critical role by transforming raw data into an organized structure, elucidating its meaning and contextual relevance to the research subject. In this study, the process employed thematic analysis during data analysis and interpretation, and the subsequent findings were deliberated upon in alignment with the emerging themes. The discussion of the findings followed the broader themes and the emerging themes.

4.3.1 Knowledge Management Practices and best practices

Knowledge management (KM) practices and best practices play a crucial role in organizations by enabling them to capture, store, share, and leverage their collective knowledge and expertise. Effective KM can improve decision-making, foster innovation, enhance productivity, and drive organizational growth.

4.3.1.1 Knowledge Management Strategies and Practices

The findings from this study provide a comprehensive view of the knowledge management strategies and practices in the renewable energy sector, highlighting their pivotal role in fostering innovation and collaboration among sector stakeholders. These strategies encompass a range of approaches, including knowledge sharing platforms, collaborative endeavors, data-driven insights, and educational initiatives.

One significant subtheme is the prevalence of knowledge sharing platforms within organizations, which offer a space for employees and stakeholders to exchange valuable information, research findings, best practices, and lessons learned. Participant 1 emphasized the prevalence of knowledge sharing platforms within organizations, such as intranet portals, wikis, and online forums, enabling the exchange of information, research results, best practices, and lessons learned among employees and sector stakeholders. Participant 2 highlighted the importance of collaboration between organizations, research institutions, and government agencies to advance technology and develop innovative solutions. In resonance, Simões *et al.*, (2018:1703-1713) attested that the collection and sharing of data, encompassing weather statistics, energy production data, and grid performance metrics, provide a foundation for collaboration and innovation.

Furthermore, conferences and seminars, as noted by Participant 4, serve as essential forums where experts and professionals convene to discuss the latest developments, facilitating the exchange of knowledge and ideas. The involvement of sector associations and consortia in advocating for sector interests and promoting inter-company collaboration strengthens the sector's unity. This culture of knowledge sharing and collaboration not only accelerates technological progress but also supports the development of standardized practices and technologies, making it more

convenient for stakeholders to collaborate and integrate renewable energy systems (Twidell, 2021:67-71). Therefore, these knowledge management strategies are pivotal in driving innovation, fostering a collaborative ecosystem, and advancing the renewable energy sector.

4.3.1.2 Impact of knowledge management on the effective adoption and operation of renewable energy technologies

The findings from participants in the renewable energy sector underscore the multifaceted and critical role of knowledge management in the effective adoption and operation of renewable energy technologies. Participants collectively emphasize that knowledge management facilitates the transfer of expertise and best practices, creating an environment where experienced individuals can impart their knowledge to newcomers and where the most effective approaches in design, installation, operation, and maintenance are identified and shared. In concurrence, Smith et al., (2020:41) articulated that knowledge management fosters innovation and interdisciplinary collaboration, bridging the gaps between engineering, environmental science, and policy development to address the complex challenges associated with renewable energy adoption. It also extends to data management and analysis, essential for optimizing system performance.

Moreover, knowledge management supports security and regulatory compliance, ensuring the safety of workers and the environment while minimizing legal and financial risks. Furthermore, it plays a role in influencing renewable energy policy and regulations by facilitating data collection and knowledge sharing among sector stakeholders, ultimately promoting the wider adoption of renewable energy technologies. By and large, Smith and Brown (2021:93) echoed the findings by stating that knowledge management extends to public awareness and education campaigns, crucial for encouraging broader acceptance and understanding of renewable energy solutions.

4.3.1.3 Shared Knowledge in Addressing Interconnected Challenges and Fostering Sustainable Development

The insights provided by participants underscore the pivotal role of shared knowledge in addressing interconnected challenges and driving sustainable development in the renewable energy industry. The participants affirmed that shared knowledge promotes collaboration and effective problem-solving among stakeholders from diverse sectors, facilitating a comprehensive approach to address multifaceted challenges. This includes everything from grid integration to mitigating environmental impacts. In this regard, Ernst and Young (2021:21) enunciated that policymakers rely on shared knowledge to craft effective regulations, while project stakeholders benefit from shared insights on finance, risk assessment, and insurance, reducing operational and financial risks. Knowledge dissemination also extends to public education, technology transfer, and capacity building, allowing regions to benefit from others' expertise and accelerate renewable energy deployment.

Furthermore, collaborative research and data-sharing initiatives aid in understanding the impacts of renewable projects, leading to sustainability-driven corrective measures. Furthermore, shared knowledge supports market growth by providing market insights, consumer preferences, and emerging technologies, enabling informed decision-making and resource allocation (Govender *et al.*, 2019:128). Finally, international cooperation and knowledge exchange enable cross-border learning and the pursuit of global sustainable development objectives.

4.3.2 Key Barriers and Facilitators That Impact the Effectiveness of Knowledge Management

Key barriers and facilitators play a crucial role in shaping the effectiveness of knowledge management (KM) initiatives within organizations. These factors can significantly influence how well knowledge is captured, shared, and leveraged.

4.3.2.1 Key Technical and Technological Challenges Facing the Expansion of Renewable Energy

The responses from participants highlight several key technical and technological challenges facing the expansion of renewable energy in South Africa, along with the

strategies to address them. One pressing challenge is the intermittency of renewable sources, which can strain the grid's reliability and stability. The inadequate energy storage infrastructure poses another hurdle, but steps are being taken to develop energy storage projects, such as utility-scale battery installations, to balance the grid. Also, the access to finance, particularly for small-scale and community-based projects, remains a challenge, but financial support and incentives are being provided by the government, international organizations, and investors to stimulate investment in renewable energy projects.

Furthermore, the expansion and modernization of transmission and distribution infrastructure are essential to accommodate the growth in renewable energy capacity. Nkambule and Smith (2020) supported the findings by arguing that a skilled workforce is vital for the construction, operation, and maintenance of renewable projects, and efforts are underway to develop a skilled workforce through training and capacity-building programs. Additionally, clear, consistent, and supportive policy and regulatory frameworks are critical, and South Africa has committed to providing a stable and transparent regulatory environment, including feed-in tariffs and power purchase agreements, to attract investment and facilitate renewable energy project development. These efforts collectively aim to surmount the technical challenges and promote the expansion of renewable energy in South Africa.

4.3.2.2 Primary Barriers to Effective Knowledge Management in the Renewable Energy Sector

The findings from participants in the renewable energy sector in South Africa highlight a multitude of primary barriers to effective knowledge management and their subsequent impact on the industry's progress. These challenges include inadequate data collection and sharing mechanisms, which hinder informed decision-making and research. Limited R&D funding stifles the development of innovative technologies and slows progress in cost reduction and efficiency improvement. Skill shortages and regulatory uncertainties affect workforce quality and long-term planning, while the absence of centralized knowledge-sharing platforms limits collective learning. High upfront costs and financing barriers impede project development and deployment.

Also, the limited collaboration and communication among stakeholders' hamper industry-wide coordination, and challenges related to permits and grid connections create delays in project deployment. Public concerns and a lack of sector standards further complicate project development and quality consistency (Department of Science and Innovation, 2020:30). These barriers collectively hinder the industry's growth and its ability to fully harness the potential of renewable energy solutions.

4.3.2.3 Ways Barriers Manifest in the Renewable Energy Innovation and Operations

The participants in their responses identified barriers to effective knowledge management in the renewable energy sector significantly impact innovation and day-to-day operations. The insufficiency of data can lead to suboptimal decision-making in project siting and resource assessment, reducing the efficiency and reliability of renewable energy systems. A shortage of skilled personnel can result in poor project execution and maintenance practices, further diminishing overall system performance. Also, frequent regulatory and policy changes create uncertainty for investors and project developers, causing project delays and cost overruns.

Furthermore, the participants affirmed that the absence of an effective knowledge-sharing platform prevents the capture of best practices and lessons learned, leading to repeated errors and missed opportunities for efficiency enhancements. In this regard, high upfront costs and limited financing options prevent projects from even reaching the planning stage, reducing innovation and renewable energy capacity. Limited collaboration among stakeholders results in fragmented efforts and misalignment on shared goals, slowing the pace of innovation and project development. In resonance, Govender *et al.*, (2019:128) attested that the lack of sector standards causes inefficiencies, interoperability issues, and increased costs, limiting the scalability of renewable energy solutions. These barriers collectively hamper both innovation and daily operations within the renewable energy sector in South Africa, underscoring the need for targeted solutions and strategies to overcome them.

4.3.3 Current State of Renewable Energy in South Africa

South Africa has been actively pursuing renewable energy projects as part of its energy mix. The Renewable Energy Independent Power Producer Procurement (REIPPP) program has been a significant driver of renewable energy installations in the country. However, the current state of renewable energy in South Africa manifests in various dimensions.

4.3.3.1 Current Status of Renewable Energy Management and Future Prospects in South Africa

The views from the participants regarding the current status of renewable energy management in South Africa suggest a positive trajectory for the industry. South Africa's Renewable Energy Independent Power Producer Procurement (REIPPP) scheme has successfully attracted private sector investment and expertise, resulting in the development of solar and wind energy projects that contribute to the national electricity grid. Several operational renewable energy projects, including solar photovoltaics and wind farms, have diversified the energy mix and reduced the country's reliance on fossil fuels. The integration of renewable energy into the grid has become smoother, and South Africa is poised to continue expanding its renewable energy capacity, setting ambitious targets to diversify its energy mix.

The future prospects for South Africa's renewable energy sector appear promising. The adoption of energy storage solutions is expected to increase, further enhancing grid reliability and enabling greater integration of variable renewable sources. As posited by REIPPPP (2021:21), the continued technological advances in renewable energy are anticipated, leading to increased efficiencies and reduced costs, bolstering the competitiveness of renewables. The sector is expected to grow both regionally and locally, with smaller-scale renewable energy projects, including community-owned facilities, playing an increasingly important role. The investments in grid upgrades and infrastructure enhancements are recognized as critical to ensure efficient grid integration and the successful management of renewable energy. South Africa's commitment to renewable energy expansion, technological advancements, and a skilled workforce bodes well for the sector's future, contributing to a more sustainable and diverse energy landscape.

4.3.3.2 Policies and Initiatives' Influence On the Growth and Development of Renewable Energy Projects in South Africa

The policies and initiatives, particularly the Renewable Energy Independent Power Producer Procurement (REIPPP) program, have played a pivotal role in influencing the growth and development of renewable energy projects in South Africa. The competitive bidding process of the REIPPP scheme has successfully attracted private sector investment, encouraging independent power producers (IPPs) to develop and operate renewable energy facilities. This private investment has injected significant capital into the renewable energy sector, fostering the development of renewable energy capacity. According to Nkambule and Smith (2020), the impact extends to diversifying South Africa's energy mix, reducing the nation's dependence on fossil fuels, and contributing to a cleaner and more sustainable energy landscape. The scheme has led to a substantial increase in renewable energy capacity, not only meeting the country's electricity needs but also providing a strong foundation for further expansion of the industry.

Moreover, the participants affirmed that the REIPPP scheme has acted as a catalyst for technological advancement and innovation in renewable energy projects. Developers are incentivized to find more efficient and cost-effective ways to generate electricity from renewable sources, driving sector progress. Grid integration has improved as renewable energy projects have grown, enhancing grid management and stability to accommodate intermittent renewable sources and ensure national grid reliability. Department of Science and Innovation (2020:30) echoed the findings by stating that the policies and initiatives prioritize sustainable development and environmental mitigation, encouraging renewable projects to incorporate sustainability measures that lead to emissions reduction and community engagement. Additionally, transparent procurement processes and long-term power purchase agreements (PPAs) have boosted investor confidence, making South Africa an attractive destination for local and international investors in renewable energy.

4.3.3.3 Measures in Place to Ensure the Sector's Long-Term Sustainability and Success

The participants acknowledged that to ensure the long-term sustainability and success of South Africa's renewable energy sector as it makes an increasingly significant contribution to the nation's electricity generation, a comprehensive set of measures and strategies are being implemented. The Integrated Resource Plan (IRP) plays a vital role in providing a clear and structured framework for the energy sector's development, setting generation targets and outlining plans for increasing renewable energy capacity over the long term. The Renewable Energy Independent Power Producer Procurement (REIPPP) scheme remains at the core of these efforts, utilizing competitive bidding and long-term power purchase agreements to ensure steady growth and attract private sector investment.

In addition to these measures, South Africa is committed to holding more rounds of competitive tendering under the REIPPP scheme, encouraging the development of new renewable energy projects and fostering cost-competitive solutions. Investments in grid infrastructure and energy storage solutions are enhancing grid stability, critical for accommodating the variability of renewable energy. Collaboration between governments, research institutions, and sector stakeholders on research and development activities is driving technological advancements, improving the efficiency of renewable energy systems, and reducing costs. Sustainability principles are being incorporated into projects to minimize environmental and social impacts, strengthening the industry's acceptance and success (Department of Science and Innovation, 2020:30). Promoting small-scale renewable projects and community ownership initiatives align with regional and local development goals and contribute to energy independence.

4.3.4 Integration of an Improved Knowledge Management Framework Within the Renewable Energy

Integrating an improved knowledge management framework within the renewable energy sector can be highly beneficial for enhancing research, development, and the efficient utilization of renewable energy resources. Such integration can lead to better decision-making, innovation, and collaboration within the industry. As deduced from

the participants emerging themes were key project-specific risks faced by renewable energy projects, policies' creation of a favourable environment for technology adoption in South Africa renewable energy sector and the on-going efforts and initiatives to ensure sustainability of renewable energy.

4.3.4.1 Key Project-Specific Risks Faced by Renewable Energy Projects

The participants collectively attested that renewable energy projects in South Africa encounter a range of project-specific risks, and the strategies employed to mitigate these risks are integral to ensuring project resilience and success. Some of these key risks include grid connection delays, resource unpredictability, opposition from local communities or environmental groups, financial uncertainties, land rights and permitting challenges, technical issues, market fluctuations, and changes in laws and regulations. To address grid connection risks, South Africa has invested in grid infrastructure and established clear grid connection rules. This ensures timely connection and requires developers to meet grid code requirements, enhancing grid stability. Resource unpredictability, a common challenge for wind and solar projects, is mitigated by employing detailed resource assessments and advanced weather forecasting techniques to improve resource predictability.

Also, the financial uncertainties due to factors like currency exchange rate fluctuations are mitigated by using long-term power purchase agreements (PPAs) with fixed electricity prices, currency hedging, and transparent project financing to reduce financial uncertainty and attract investors. Land rights and permitting challenges can lead to delays and increased costs, but responsible land use planning, early engagement with relevant authorities, and compliance with permitting requirements streamline the process. Technical issues and equipment failures are reduced through regular maintenance, performance monitoring, and the use of high-quality equipment and technology.

Market fluctuations and policy uncertainties are mitigated through a diversified energy mix, long-term power purchase agreements, and government-supported renewable energy policies that stabilize project revenue and reduce market risks (Department of Science and Innovation, 2020:30). Finally, to address changes in laws and regulations, South Africa aims to provide regulatory stability and transparency, creating an enabling

environment for renewable energy projects with stable feed-in tariffs and transparent procurement processes, thereby minimizing legal and regulatory risks.

4.3.4.2 Policies' Creation of a Favorable Environment for Technology Adoption in South Africa's Renewable Energy Industry

The policies like feed-in tariffs, renewable energy targets, and tax incentives were posited by the participants as playing a pivotal role in fostering a favorable environment for technology adoption in South Africa's renewable energy industry. Feed-in tariffs provide financial incentives to renewable energy producers, encouraging investment in technologies like solar and wind. Renewable energy targets provide a clear direction for the sector and signal the government's commitment to clean energy adoption, which, in turn, drives investment in various renewable technologies.

To ensure policy stability and consistency, South Africa has transitioned from feed-in tariffs to competitive bidding processes, as exemplified by the Renewable Energy Independent Power Producer Procurement (REIPPP) scheme. The development of a tax incentive scheme for renewable energy projects, along with its incorporation into relevant tax legislation, has created a stable and consistent framework for technology adoption. A clear and transparent regulatory framework, including long-term power purchase agreements (PPAs) and grid integration rules, facilitates technology adoption and grid connectivity. According to Department of Science and Innovation (2020:29), the diversification of markets, covering various renewable technologies like onshore and offshore wind, solar photovoltaics, concentrated solar power (CSP), and biomass, encourages technological diversity and innovation while reducing reliance on a single technology type. Moreover, collaboration between the South African government, sector representatives, and stakeholders ensures that policies and regulations remain balanced and meet the needs of all interested parties. These measures contribute to a stable, consistent, and investor-friendly environment, fostering the continued growth of the renewable energy sector in South Africa.

4.3.4.3 Ongoing Efforts and Initiatives to Accelerate Technology Innovation in the South African Renewable Energy Sector

The majority of the participants also acknowledged that the ongoing efforts and initiatives in the South African renewable energy sector to accelerate technological innovation are multifaceted, with a focus on collaboration, research and development, and education and training. The sector encourages collaboration between the public and private sectors, fostering joint ventures and partnerships between government agencies, research institutions, and sector stakeholders. In resonance, Ngcobo and Van der Merwe (2019:54) attested that these collaborative efforts play a pivotal role in driving innovation, as they bring together diverse expertise and resources to tackle complex challenges.

More so, research and development (R&D) activities form the backbone of technology innovation in the renewable energy sector. Research institutions, universities, and sector players are actively engaged in R&D, focusing on areas like resource assessment, solar PV technology improvement, wind turbine efficiency enhancement, advanced battery systems, smart grid technologies, and more. These efforts are essential for developing cutting-edge solutions, improving the efficiency and reliability of renewable energy systems, and expanding the range of technologies available for deployment (James & Mthembu, 2018:83). These combined efforts ensure that South Africa remains at the forefront of renewable energy technology development, driving the industry's growth and sustainability.

4.4 Conclusions

The primary objective of the study is to comprehensively assess and enhance the knowledge management framework within the renewable energy sector in South Africa in order to identify, challenges, strengths, opportunities, and gaps for further research. In this regard, the conclusions deduced from the findings are discussed in this section.

4.4.1 Existing Knowledge Management Strategies and Best Practices

In ascertaining the existing knowledge management strategies and best practices employed in the South African renewable energy sector, the study concluded that there is a vibrant ecosystem of collaboration and innovation. The prevalence of knowledge

sharing platforms and collaborative efforts reflects a proactive approach to disseminating and creating knowledge within the industry. The emphasis on data collection and sharing provides a solid foundation for decision-making and innovation. Additionally, the role of conferences, educational institutions, and sector associations in facilitating knowledge exchange is noteworthy. The culture of open innovation and interdisciplinary collaboration contributes to the sector's growth and development. This therefore suggest that the South African renewable energy sector recognizes the importance of knowledge management as a driver of innovation and sustainability.

The impact of knowledge management on the effective adoption and operation of renewable energy technologies is multifaceted. It serves as a conduit for transferring expertise and best practices, reducing errors, enhancing performance, and supporting continuous improvement. The emphasis on innovation and interdisciplinary collaboration highlights the complexity of challenges in the sector, necessitating a holistic approach to problem-solving. Furthermore, the role of knowledge management in policy influence and public awareness demonstrates its far-reaching impact. By fostering collaboration, ensuring security and compliance, and supporting data-driven decision-making, knowledge management is at the heart of advancing renewable energy technologies in South Africa.

4.4.2 Key Barriers and Facilitators that Impact the Effectiveness of Knowledge Management

In determining the key barriers and facilitators that impact the effectiveness of knowledge management in the context of renewable energy in South Africa, the study concluded that there are obstacles towards effective renewable energy. The access to finance, especially for smaller-scale projects, remains a challenge, but the government's financial support, along with incentives and investments from international organizations, is stimulating the sector. Moreover, the expansion and modernization of transmission and distribution infrastructure are critical to accommodating the growth in renewable energy capacity. A clear and supportive policy and regulatory frameworks are vital, and South Africa's commitment to providing such a stable and transparent environment, including feed-in tariffs and power purchase agreements, is attracting investment and promoting a conducive atmosphere for renewable energy projects. These combined strategies and measures are critical

for addressing the technical challenges and enabling the expansion of renewable energy in South Africa.

In the context of the primary barriers to effective knowledge management in South Africa's renewable energy sector, it's evident that these obstacles have significant repercussions for innovation and daily operations. Regulatory uncertainties create an unpredictable environment that discourages long-term planning and investment. The lack of centralized knowledge-sharing platforms restricts the industry's ability to learn collectively and apply best practices. Also, the public concerns and a lack of sector standards further complicate development and consistency, negatively impacting both innovation and operational progress. These findings highlight the urgency of addressing these knowledge management barriers to unlock the full potential of renewable energy in South Africa and promote sustainable progress.

4.4.3 Current State of Renewable Energy in South Africa

In ascertaining the current state of renewable energy in South Africa and how can the knowledge management framework be effectively integrated into policy and regulatory frameworks to support renewable energy deployment, the study concluded that it is important to recognize the pivotal role of knowledge management in addressing interconnected challenges and driving sustainable development in the renewable energy industry. Shared knowledge, which facilitates collaboration and effective problem-solving among diverse stakeholders, is essential for taking a comprehensive approach to addressing multifaceted challenges. This approach extends from grid integration to mitigating environmental impacts and goes beyond regulatory compliance to impact sustainable development across various sectors.

To effectively integrate knowledge management into policy and regulatory frameworks, South Africa can develop policies that explicitly require knowledge sharing and collaboration among stakeholders. South Africa can also consider incentives for knowledge-sharing efforts, such as tax incentives or grants for organizations and projects that actively engage in knowledge management practices. Additionally, regularly reviewing and updating policies to align with the evolving renewable energy landscape and the latest knowledge can be crucial for continued success. Finally, the government can play a significant role in promoting knowledge management by

actively participating in data-sharing initiatives, supporting research and development activities, and facilitating collaboration among sector players to address shared challenges and drive innovation.

4.4.4 Interventions for the Success of Renewable Energy Projects

The study's key conclusion is the importance of evidence-based recommendations to enhance the success and resilience of renewable energy projects in South Africa, given their susceptibility to project-specific risks. Proactive collaboration among project developers, local communities, and environmental groups is a fundamental step in addressing opposition and permitting challenges, fostering trust, effective communication, and shared benefits. To mitigate financial uncertainties due to currency exchange rate fluctuations, the implementation of currency hedging mechanisms in long-term power purchase agreements (PPAs) should be considered, providing financial stability for investors. Streamlining grid connection processes, maintaining grid infrastructure investments, and establishing clear connection rules are crucial to address grid connection delays and enhance grid stability. Advanced weather forecasting and data-driven resource assessments can improve predictability and project performance in light of resource unpredictability. Lastly, maintaining long-term PPAs and a consistent regulatory framework is essential to manage market fluctuations and regulatory uncertainties.

Additionally, South Africa should continue its transition to competitive bidding processes like the Renewable Energy Independent Power Producer Procurement (REIPPP) scheme to create a favorable environment for technology adoption. Developing a comprehensive tax incentive scheme and integrating it into relevant tax legislation is essential for consistent financial support for technology adoption. Proactive engagement with stakeholders for policy dialogues and adjustments, alongside investment in research and development programs, will stimulate technological innovation, cost reduction, and technology adoption. Promoting diversified markets and international collaboration with global partners and organizations will leverage expertise and resources for technology adoption, establishing a comprehensive strategy focusing on competitive auctions, tax incentives, policy stability, R&D, capacity-building, and international collaboration to advance South Africa's renewable energy industry.

4.5 Recommendations to the Study

Given the conclusions of the study, the following are recommendations from the study:

4.5.1 Establish a Centralized Knowledge Sharing Platform

To address the limited availability of centralized knowledge-sharing platforms, it is recommended to create a dedicated and comprehensive platform that facilitates the exchange of best practices, lessons learned, and research findings within the South African renewable energy sector. This platform can serve as a repository of information, case studies, and resources, enabling stakeholders to access and contribute knowledge. By centralizing knowledge sharing, the sector can collectively learn from past experiences, optimize decision-making, and foster a culture of continuous improvement.

4.5.2 Promote Interdisciplinary Collaboration

Recognizing the complex challenges in the renewable energy sector, encourage and incentivize interdisciplinary collaboration among various stakeholders, including engineers, environmental scientists, policymakers, and sector experts. Establish collaborative projects that bring together diverse expertise to tackle multifaceted issues, such as grid integration, environmental impact mitigation, and policy development. Promoting interdisciplinary collaboration can lead to innovative solutions and holistic problem-solving approaches that drive the sector's growth and development.

4.5.3 Address Regulatory Uncertainties

To mitigate the impact of regulatory uncertainties on the sector's knowledge management, advocate for clear, consistent, and stable regulatory frameworks. Engage with policymakers, sector associations, and relevant authorities to create an environment that provides transparency, regulatory stability, and long-term planning horizons. This includes ensuring that feed-in tariffs, power purchase agreements, and permitting processes are well-defined and predictable. Regulatory stability not only attracts investment but also supports knowledge management by offering a reliable foundation for decision-making and innovation within the renewable energy sector.

4.5.4 Government Participation

The government should actively participate in data-sharing initiatives, support research and development activities, and facilitate collaboration among sector players. The government's commitment to knowledge management can set a strong example for the entire sector.

4.6 Areas for Further Study

The primary objective of the study is to comprehensively assess and enhance the knowledge management framework within the renewable energy sector in South Africa in order to identify, challenges, strengths, opportunities, and gaps for further research. In this regard, the areas for further research are outlined below:

- **Comparative Regional Studies:** Investigate and compare the knowledge management frameworks and practices in renewable energy across different provinces or regions in South Africa. This comparative analysis could shed light on regional variations and the impact of local factors on knowledge management effectiveness.
- **Cross-Sector Knowledge Transfer:** This research could explore the adaptability of cross-sector knowledge transfer and its potential benefits.
- **Technological Innovation:** Research the role of knowledge management in driving technological innovation in renewable energy within Gauteng.
- **Impact on Sustainable Development:** Investigate the relationship between knowledge management in renewable energy and its impact on broader sustainable development goals within Gauteng.
- **Barriers and Facilitators for Knowledge Sharing:** Explore the specific barriers and facilitators that influence knowledge sharing in the Gauteng renewable energy sector. Identify the challenges and opportunities faced by organizations and stakeholders in this region.

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APPENDICES

Appendix A: Informed Consent

11/11/2023

DEAR PARTICIPANT

INFORMED CONSENT TO PARTICIPATE IN INTERVIEW

You are invited to participate in a research study. Before you decide whether or not to participate, it is important for you to understand the purpose of the study, its procedures, potential risks and benefits, and your rights as a participant. Please take the time to read the following information carefully. Feel free to ask any questions you may have before making your decision. Your participation in this study is entirely voluntary.

Since you have practical knowledge of management in a power plant for the generation of renewable energy, you have been invited to take part in this research study. Your experiences in [role/position] at [Company] will give you insightful perspectives on the problems, solutions, possibilities, and gaps.

Title of the project: Exploring the knowledge management framework renewable energy in the South African Environment.

Principal Investigator: Mr. JC Coetzee

Email Address: Johannes.Coetzee@nwu.ac.za

Contact no: +27

Researcher: Mr. PS Mashaba

Email Address: mashabaprm@gmail.com

Contact no: +27 72 875 2785

Institution: NWU Business School

Ethical Clearance Number: [N W U – 0 1 8 8 0 – 2 3 – A 4].

Purpose of the Study:

The purpose of this research is to explore the knowledge management framework of renewable energy in South Africa and identify, challenges, strengths, opportunities, and gaps for further research. The research will contribute to the development of a comprehensive management knowledge framework for renewable energy in South Africa and provide evidence-based recommendations for policymakers, Investors, and other stakeholders.

Expectations from the participant

You will be expected to:

- Participate in a 30- to 45-minute semi-structured interview with the researcher via an online platform or face-to-face at a convenient time. Once the NWU ethical committee has given its approval, the researcher will schedule this.
- Respond to the questions in an open and honest manner.
- In the event that you encounter any sort of discomfort or distress while conducting the research, please contact the supervisor. You should also let them know if you occasionally feel the need to stop participating in the research procedure.

Risks and Discomforts:

Since there are no physical exercises or experiments included in the study, taking part poses no risk to your health. But in order to protect you, we've set some moral standards that must be upheld at all times. These guidelines will put protecting your dignity and maintaining the privacy and confidentiality of all records you supply first.

Benefits:

This research study aims to give you a platform to discuss, share, and reflect on the main success elements and decision-making criteria you have used to expand your company. For taking part in the study, there will be no financial compensation. However, you will receive a two-page communiqué on the study's findings that you can use to get ready for the interview.

Confidentiality:

You'll receive a special participant ID. However, the information gathered will be treated as confidential and won't be disclosed to anyone who isn't directly involved in the study process. Our conversation will be recorded and preserved with a reference to the ID. Participants' direct contributions to the research study as well as their personal information must remain confidential. All research records must be retained for a set amount of time before being properly destroyed. The study's conclusions will be made public, but they won't include any unprocessed information that might implicate specific people.

Findings of the study:

The findings of the study will only be used to advance academic research and the body of currently accessible information. A two-page communiqué will be sent via email to study participants, upon request, informing them of the study's findings. On request, the electronic dissertation final version will also be made available.

Voluntary Participation and Right to Withdraw:

You have the freedom to voluntarily withdraw from this study at any time and without giving a reason. It might not be possible to delete your information from the study once the data has been de-identified and aggregated. Please get in touch with the supervisor if you experience any form of discomfort or distress while conducting the research. They should be informed if they ever feel the need to quit taking part in the study process.

Data Management

Data will be handled and managed in compliance with the POPI Act (Protection of Personal Information Act) which prevents the misuse of personal information. All participant consent will be obtained before collecting any data from them, and all information will be protected throughout the whole data collection and analysis procedure for this study. In accordance with the PAIA, information will be available for participants to later recall their information until the date of destruction.

Statement of Consent:

Statement of consent	Please Mark with X	
I have read and understood the information provided in this consent form.	X	
I have had the opportunity to ask questions, and any concerns I raised have been addressed to my satisfaction.	X	
I voluntarily agree to participate in this study and consent to the collection, use, and storage of my data as described.	X	
I understand that my participation is entirely voluntary and that I may withdraw from the study at any time without penalty or loss of benefits.	X	

Participant's Signature:



Date: 11/11/2023

Investigator's Signature: _____

Date:

Appendix B: Research Instrument

Thank you for participating in this semi-structured interview. Your insights are incredibly valuable to our research, and we genuinely appreciate your time and willingness to share your experiences. The purpose of this study is to gain a deeper understanding of the knowledge management framework of renewable energy in South Africa and to identify challenges, strengths, opportunities, and gaps for further research. and other stakeholders. and your perspective will play a crucial role in achieving that goal.

The research will contribute to the development of a comprehensive management knowledge framework for renewable energy in South Africa and provide evidence-based recommendations for policymakers, Investors, and other stakeholders.

Please know that all information shared during this interview will be treated with the utmost confidentiality and will only be used for research purposes. Your name and any identifying information will be kept confidential, and your responses will be reported anonymously in our final research report.

This interview will follow a semi-structured format, allowing us to have a guided conversation while still giving you the flexibility to express your thoughts freely. We encourage you to share any relevant experiences, opinions, or insights you may have related to the questions we will be discussing.

Before we begin, please feel free to ask any questions you may have about the interview process or the research itself. Your comfort and understanding are essential to us. Once again, we thank you for your participation, and we look forward to gaining valuable insights from your responses.

Respondent's code.....

SECTION A: Demographic Information, Intruduction and Background

Demographic Information:

Organization.....

Position in the
organization.....

Duration of Service in Current Position

Age.....

Introduction and Background:

Can you please introduce yourself and describe your role or expertise in the field of renewable energy ?

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Section B: Knowledge Management Practices and best practices

- *Objective one: Investigate the existing knowledge management strategies and best practices employed in the South African renewable energy sector*

What specific knowledge management strategies and practices have you observed in the renewable energy sector, and how do these contribute to innovation and collaboration among industry stakeholders?

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In your experience, how has knowledge management impact on the effective adoption and operation of renewable energy technologies?

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Can you explain how shared knowledge has been instrumental in addressing interconnected challenges and fostering sustainable development in the industry?

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Section C: Key Barriers And Facilitators That Impact The Effectiveness Of Knowledge Management

- *Objective Two: Analyse the key barriers and facilitators that impact the effectiveness of knowledge management in the context of renewable energy in South Africa;*

What are the key technical and technological challenges facing the expansion of renewable energy in South Africa, and how are they being addressed?

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What, in your experience, have been the primary barriers to effective knowledge management in the renewable energy sector in South Africa, and how have these obstacles impacted the industry's progress?

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In what ways does the key barriers manifest in the renewable energy innovation and operations?

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Section D: Current state of renewable energy in South Africa

- *Objective three: Investigate the current state of renewable energy in South Africa and how can the knowledge management framework be effectively integrated into policy and regulatory frameworks to support renewable energy deployment.*

What is the current status of renewable energy management in South Africa and what are the future prospects?

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How have the policies and initiatives, such as the Renewable Energy Independent Power Producer Procurement (REIPPP) program, influenced the growth and development of renewable energy projects in South Africa?

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Given the increasing contribution of renewable energy to South Africa's electricity generation, what measures are in place to ensure the sector's long-term sustainability and success?

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Section E: Integration Of An Improved Knowledge Management Framework Within The Renewable Energy

- *Objective Four: Formulate evidence-based recommendations for the development and integration of an improved knowledge management framework within the renewable energy in South Africa.*

What are some key project-specific risks faced by renewable energy projects in South Africa, and how have they been mitigated to ensure project resilience and success?

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How have policies like feed-in tariffs, renewable energy targets, and tax incentives created a favorable environment for technology adoption in South Africa's renewable energy industry, and what measures are in place to ensure policy stability and consistency?

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Could you discuss ongoing efforts and initiatives to accelerate technology innovation in the South African renewable energy sector and the role of research and development in this process?