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Towards standardized project management practices to improve renewable energy based microgrid design and deployment in South Africa

Fiona Oloo

(Student number: 790305)

School of Mechanical and Aeronautical Engineering

University of the Witwatersrand

Johannesburg, South Africa.

Supervisor: Dr Bernadette Sunjka

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05 September 2025

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Abstract

The deployment of renewable energy (RE) microgrid projects in South Africa faces significant project management challenges that impact efficiency and success. This study investigates project management practices in RE microgrid projects, identifying key success factors, challenges, and potential solutions. Through a critical literature review and two sets of semi-structured interviews, the research examines commonly used project management frameworks and methodologies, including PMBOK, CPM, CCPM, PERT, Waterfall, and PRINCE2 and also considers methodologies not common to the RE space such as Agile and Lean. Findings reveal that the Waterfall method is the most widely used due to its simplicity, though its rigidity presents limitations in adapting to project changes. The study highlights critical success factors such as leadership, communication, stakeholder engagement, and context-specific solutions. Key challenges identified include leadership and communication deficits, adapting solutions to local contexts, and project scope management. In addition, risk management is considered a priority concern across the project lifecycle. Based on these findings, the study proposes standardized project management practices tailored to the South African context. These recommendations include defining clear project success criteria, improving stakeholder and risk management, and incorporating complementary project management approaches to address existing shortcomings. The alignment between literature findings and participant feedback suggests the practical applicability of these recommendations. While this research provides actionable insights for improving RE microgrid project deployment, its scope is limited by the participant sample size. Future studies could expand on these findings by including a more diverse range of professionals to further refine best practices. This study contributes to addressing the challenges of RE microgrid deployment in South Africa by offering actionable recommendations. These insights aim to enhance the efficiency and success of microgrid projects, providing a foundation for improving energy access and sustainability in the region.

Dedication

I would like to dedicate this research to my family, particularly my mother Rebecca and my sisters Leslie, Sonia and Renee. I'd also like to dedicate this to my partner, Pitsi and my best friend Boitumelo for always believing in me, even when I doubted myself. Your love and encouragement made this possible.

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Contents

CHAPTER 1 7
INTRODUCTORY CHAPTER 7
1.1 RESEARCH BACKGROUND 7
1.2 PROBLEM STATEMENT/MOTIVATION 8
1.3 RESEARCH QUESTION/S 9
1.4 RESEARCH OBJECTIVES 9
1.5. SUMMARY OF RESEARCH METHOD 9
1.6. DELIMITATIONS 10
1.7 OUTLINE OF CHAPTERS 10
CHAPTER 2 12
LITERATURE REVIEW 12
2.1 Features of Renewable Energy (RE) projects 12
2.2. Successfully Used Project Management Practices and Frameworks in the Renewable Energy Space 14
2.2.1. Project Management Body of Knowledge (PMBOK) 14
2.2.2. Critical Path Method (CPM) 16
2.2.3. Project Evaluation and Review Technique (PERT) 17
2.2.4. Critical Chain Project Management Method (CCPM) 18
2.2.5. Waterfall methodology 20
2.2.6. PRINCE2 methodology 21
2.2.7. Agile and Lean methodologies 21
2.2.8. Summary 23
2.3. Challenges in renewable energy project management 24
2.4. Identification of successful practices for RE project management 28
2.4.1. Identification of successful practices for RE microgrid project management 30
2.5. Requirements for successful for renewable energy microgrid project management 31
2.6. Conceptual framework - A priori theme development 40
CHAPTER 3 43
RESEARCH METHODS 43
3.1. Research Design 43
3.2. Instrumentation 44

3.3. Sampling 47
3.4. Data Collection 47
3.5. Data Analysis 48
3.6. Validity and Reliability 49
CHAPTER 4 51
RESULTS 51
4.1. Participant profile 51
4.2. Development of themes 52
4.2.1. Part A - Familiarity and use of project management frameworks and tools used for renewable energy projects and RE microgrid projects 52
4.2.2. Part B - Gaps and challenges regarding project management in renewable energy microgrid deployment in South Africa 59
4.2.3. Thematic analysis 66
4.2.3.1. Impact of the themes (Figure 14) on project efficiency (second set of interviews) . 67
CHAPTER 5 69
DISCUSSION 69
5.1. Project management frameworks for RE microgrid projects 69
5.2. Successful RE microgrid project management practices 70
5.3. Challenges in RE microgrid project management 72
5.4. Requirements for successful RE microgrid project deployment 74
CHAPTER 6 76
DEVELOPMENT OF RECOMMENDATIONS OF PROJECT MANAGEMENT PRACTICES FOR THE SUCCESSFUL DEPLOYMENT OF MICROGRIDS BASED ON LITERATURE REVIEW AND SEMI-STRUCTURED INTERVIEW INPUTS 76
6.1. Project management tools and techniques 76
6.2. Project success criteria 76
6.3. Project management style and skills 77
6.4. Standardized project management practices for RE microgrids 81
6.5. Contributions of research and limitations 84
CHAPTER 7 86
CONCLUSION 86
REFERENCES 87
APPENDICES 92
5. Appendix A – Interview questions 92
6. Appendix B: Code development and participant ranking 97

7. Appendix C – Second set of interviews feedback – Question 1 117

List of Figures

Figure 1: PMBOK framework (Project Managment Institute, 2000, p. 13) 15
Figure 2:Project Management Life Cycle. (Project Managment Institute, 2000, p. 13)..... 16
Figure 3: Basic steps in CPM (Sri Vidya College of Engineering and Technology, 2021). 17
Figure 4: Fever chart. Adapted from (Bahnas et al. 2024) 19
Figure 5: Waterfall methodology phases (Kissflow, 2024) 21
Figure 6:General success criteria for successful projects Little (2011) 32
Figure 7:A priori themes 42
Figure 8: Detailed map of research process 44
Figure 9: CRQ-> TQ->IQ Pyramid model 45
Figure 10: Data analysis process (Braun & Clarke, 2006). 49
Figure 11: Summary of key project management skills mentioned and number of times each was mentioned..... 55
Figure 12: Overall requirements ranking by considering all participant input 58
Figure 13: Overall ranking of challenges from participants 66
Figure 14: Combined themes from literature review and interview feedback..... 67

List of Tables

Table 1:Criteria used for selection of participants 51
Table 2: Key skills mentioned by participants for project managers in the RE space..... 55
Table 3: Participant feedback for question 1 part B 59

List of acronyms

CCPM	Critical Chain Project Management
CPM	Critical Path Method
CRI	Corporate Responsibility Initiative
CRQ	Critical Research Question
DG	Distributed Generation
EIA	Environmental Impact Assessment
GHG	Greenhouse Gas
HR	Human Resources

IQ	Interview Question
IT	Information Technology
JET	Just Energy Transition
JIT	Just In Time
MFMA	Municipal Finance Management Act
NEMA	National Environmental Management Act
NGO	Non-governmental organisation
PBRM	Project Buffer and Resource Management
PERT	Project Evaluation Review Technique
PFMA	Public Finance Management Act
PM	Project Management
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PRINCE2	Projects IN Controlled Environments
PV	Photovoltaic
RE	Renewable Energy
REIPPP	Renewable Energy Independent Power Producers Programme
SDG	Sustainable Development Goals
SWOT	Strengths Weaknesses Opportunities Threats
TOC	Theory of Constraints
TQ	Theory Question
UK	United Kingdom
US	United States
WBS	Work Breakdown Structure

CHAPTER 1

INTRODUCTORY CHAPTER

1.1 RESEARCH BACKGROUND

As a result of the effects of global climate change, there has been a drive to reduce greenhouse gas (GHG) emissions which have had an adverse effect on the environment. The power generation sector is a major contributor to the GHG emissions as it is still largely fossil-fuel based. It is an approximate contributor of about two thirds of global GHG emissions (Salam, et al., 2024). Fossil fuels are finite resources and to address the challenges that fossil fuels pose, the use of renewable energy sources is growing, thus, accelerating clean energy access to communities around the world (Kozhakhmetova, et al., 2019). Renewable energy is defined as energy that arises from natural sources such as the sun (solar power) or wind (wind power) for example, and these can be considered non-finite resources as they are derived from natural phenomena (U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2024). Renewable energy resources are less polluting energy sources than fossil fuels. Given that these resources are abundantly available they are an extremely viable and attractive option as alternative power generation sources. Renewable energy generation can be located in virtually any location on the planet which means that energy access does not solely have to depend on access to existing electrical infrastructure. This indicates that standalone (i.e. off-grid) decentralized solutions can provide energy access to remote, rural communities. The focus of this research is rural South African communities. The national power grid provides energy access to 85 % of South Africans (Carbon Trust, 2017) , but challenges are still experienced such as capacity constraints. Since many of the communities in South Africa are rural and oftentimes remote, providing energy access via the existing electrical infrastructure can prove challenging and costly. Approximately 10 % of the remaining population without energy access are expected to gain energy access via off-grid microgrid solutions (Carbon Trust, 2017) as per South Africa's New Household Electrification Strategy.

Given the increasing uptake of renewable energy (RE) systems globally not only to decrease GHG emissions, but also increase energy access, microgrids that incorporate RE represent an important alternative solution. A microgrid is defined as a small-scale power system which must be able to reliably operate autonomously to supply power to a group of user/s (Danish, et al., 2019a). The design and deployment of microgrid projects, however, involves the management of several complex key aspects (such as technical, economic, environmental, and social) which means that appropriate project management practices are required to make microgrid deployments sustainable and the process repeatable and scalable.

Steyn & Labuschagne (2010) state among the different project management methods used in South Africa, in the engineering industry, which is a major driver of microgrid deployment, most of the methods used are in alignment with worldwide standards for project management such as the Project Management Body of Knowledge® (PMBOK) and PRojects in Controlled Environments (PRINCE2®).

1.2 PROBLEM STATEMENT/MOTIVATION

Piwowar-Sulej, et al. (2023) states that there have been very few studies that have synthesized the linkage with project management and renewable energy projects. It is, thus, inferred that there is scope to analyse common successful project management practices that have resulted in successful RE projects and by extension, applying these practices to RE microgrid projects. Ikejemba et al. (2017a) note that many of the causes of failure of RE projects lie in the project management and practices that are applied, with several different challenges arising at different stages of the project management process. Examples of these challenges, include the delegation of responsibilities in a project and the mismanagement of stakeholder engagement (Ikejemba, et al., 2017a). Despite the potential of RE microgrid solutions there are currently very limited standardized project management practices that aim to ensure the efficient deployment of RE microgrids for rural communities. There have been several authors that have compiled generic recommendations for improved project management of RE projects such as the work done by Ikejemba et al. (2017b) whose study uses observations and interviews with local communities in Sub-Saharan Africa, the organizations that implemented the RE projects and relevant governments. However, there is an existing research gap where common successful project management practices are identified and analysed based on experience, particularly for the South African context. Danish, et al. (2019b) observe that in the past five years, there has been no comprehensive project management framework specifically for microgrid projects. To address this gap, they propose a general framework based on PMBOK® principles. Their framework adapts standard project management practices to develop practical, customized solutions that address the management, technical, and sustainability aspects of microgrids. It aims to meet the business needs of microgrids within given constraints and ensure their long-term sustainable operation. Danish, et al. (2019b) however, also state that the framework is broad, and more detailed investigation is required for this topic.

The lack of a comprehensive framework could pose a barrier to increasing the widespread adoption of microgrids which would delay energy access to communities that require electrification. This research therefore seeks to address this gap.

1.3 RESEARCH QUESTION/S

How can a project management framework for renewable energy microgrid projects be developed to improve the efficiency of the deployment of these projects in South Africa?

1.4 RESEARCH OBJECTIVES

The objectives of this research are to:

1. Investigate successfully used project management practices in RE microgrid projects and larger scale renewable energy projects (with focus on the applying renewable energy project management practices of larger scale projects to RE microgrid projects).
2. Determine the challenges experienced in RE project management practices and requirements for successful microgrid project deployment.
3. Recommend standardized project management practices for the successful deployment of microgrids

1.5. SUMMARY OF RESEARCH METHOD

The research objectives were addressed via a literature review and the collection of qualitative data. The literature review provides a wider view of the project management practices that have been successful and the project management knowledge areas that require improvement. The type of qualitative data collected was through two rounds of semi-structured interviews with experts in the RE space that have project management experience in South African RE projects as well as a particular focus on RE microgrid deployment experience. The results for the research were derived from transcription of the online interviews with the experts in the RE space who provided review and inputs on compiled requirements for successful deployment of RE microgrids in South Africa. Apart from using a literature review to investigate challenges in project management, the interviewees provided insights from their experience about important project management challenges in South Africa. The data analysis process involves coding the data from transcriptions, grouping codes into themes, determining the relationships between themes and compiling recommendations. The input into the requirements for successful deployment of RE microgrids and the challenges in RE PM in South Africa formed part of the first set of interviews. The second set of interviews were a follow up to seek out review and input from interviewees about the recommendations for standardized PM practices for RE microgrids. This also included the recommendations for addressing the challenges in PM for RE microgrids. Expert input was used to validate the content. The ethics clearance number for this research is MIAEC 021/24.

1.6. DELIMITATIONS

The recommendations that come from the study are limited to project management rural RE microgrids in South Africa. Only qualitative methods are used in the study for data collection through semi-structured interviews. Technical aspects of RE microgrid design are not considered in this research. The results of the study are specific to South African RE microgrid projects and may not directly apply to other regions or energy types. RE microgrid projects require the use of land for implementation of projects. The National Environmental Management Act (NEMA) no. 107 of 1998 as amended in 2010 provides a framework for cooperative environmental governance and environmental principles that aid in facilitating decision-making on issues that impact the environment (Department of environmental affairs, 2013). Environmental authorisation by a competent authority (specific to provincial locations in South Africa) is required by NEMA before any construction activity related to renewable energy facility/s commence i.e., a basic assessment (Environmental Impact Assessment (EIA)) be carried out (Department of environmental affairs, 2013). For RE microgrid project this is critical and influences the likelihood that a project will be successful, however it is not analysed in detail in this research scope.

1.7 OUTLINE OF CHAPTERS

- **Chapter 2**

Chapter 2 covers features and trends in renewable energy (RE) projects. RE projects are temporary, endeavors with distinct phases, facing challenges like regulatory changes, stakeholder complexity, and technology integration. Success depends on coordination among governments, investors, and communities, along with continuous monitoring and evaluation. Trends include sustainability integration, risk management, and knowledge sharing. A review of RE project management frameworks highlighted PMBOK, CPM, CCPM, PERT, Waterfall, and PRINCE2, with Waterfall being common for South African microgrid projects because of its simplicity but it is also considered relatively rigid. Key success factors include risk management, stakeholder engagement, and communication, while challenges involve leadership, project scoping, and socio-cultural engagement.

- **Chapter 3**

Chapter 3 covers the research methods. The research methods used were a literature review and qualitative data collection via two sets of semi structured interviews. The literature review examined successful project management practices and areas that require improvement. The interviews were conducted with RE project management experts in South Africa, focusing on RE microgrid deployment. The structure of the interviews included a first round, that gathered expert feedback on compiled key requirements and challenges, and the second round gathered expert feedback on recommended standardized PM practices. The data analysis

process included transcription, coding, thematic grouping and relationship analysis between the themes. The validation process was through expert review which ensured the applicability of recommendations to the South African context.

- **Chapter 4**

Chapter 4 covers the results and analysis of the study. The results from the first set of interviews identified preferred PM tools and techniques from participants, provided insight into project management style and skill and provided a consolidated definition of what the participants considered to be project success. A ranking of compiled requirements for successful RE microgrid project deployment was performed with participants to understand higher impact requirements on project success so that the appropriate effort can be put towards these requirements. Results from the first set of interviews also considered identifying the project management challenges that occur in the RE microgrid deployment. A similar ranking of compiled challenges by participants was conducted to provide insight into the challenges that must be prioritized to be addressed in South Africa that have the greatest impact on project success. A thematic analysis was then carried out. The main themes identified were project management (PM) tools & techniques, project success criteria, PM style & skills (there are several identified subthemes under this theme), culture, and leadership.

- **Chapter 5**

This chapter is the discussion. It discusses the findings from the results and highlights existing research in relation to the results. The sections covered are successful practices, challenges in and requirements for RE microgrid project management.

- **Chapter 6**

Chapter 6 is made up of development of recommendations from the literature review, thereafter participant feedback from the second set of interviews was integrated. The second set of interviews aimed to tailor the recommendations from the literature review for the South African context.

- **Chapter 7**

Chapter 6 is the conclusion which highlights the key findings, challenges, success factors, recommendations, limitations and considerations for future research.

CHAPTER 2

LITERATURE REVIEW

The goals of the literature review are to compile a set of requirements for successful project management practices, identify a set of challenges based on the literature review identifying key areas of improvement in RE microgrid projects. This literature review begins by outlining the features of RE projects then identifying trends in RE project management. The subsequent section discusses examples of frameworks and methodologies used in the RE project management space. The next section highlights several studies that provide insight into the larger RE project management space to identify successes and potential areas of improvement. Specific studies/experiences in RE microgrid project management space are then discussed. Finally, resultant themes about the PM areas from the studies mentioned, which require improvement/further research for the RE space are summarized which contributes to forming a basis for this research project.

2.1 Features of Renewable Energy (RE) projects

A project is defined as a temporary endeavour that a project team performs to create a product or service and has a definite start and end (Project Managment Institute, 2000). Other characteristics of a projects are that the resources (e.g., human, financial, equipment etc.) are limited, projects are separated organizationally from the other activities in an organization, are associated with risk and a degree of uncertainty that decreases as the work progresses and the phases of a project can clearly be identified (Igielski, 2023). Additionally, energy projects often use considerable land area and may impact the fauna and flora in the area (Jarosz, et al., 2022). Given this impact, project management of RE projects must include a sustainability aspect since a main focus of energy projects is creating lasting value (Jarosz, et al., 2022). The value not only includes delivery of a project in terms of time, scope, cost and desired quality in its definition, but also includes the long-term effects on organizations and society (Jarosz, et al., 2022).

Project management is a process where knowledge, skills, techniques, and tools are applied to meet the requirements of a project and ensure that the desired outcomes are delivered while considering the triple constraints scope, time, and budget (Project Managment Institute, 2000). Within these definitions, RE projects have particular characteristics. Unique challenges are presented to traditional project management of renewable energy projects, and these include regulatory requirements that are frequently evolving, the complexity of stakeholder management, lengthy project lifecycles and emerging technologies (Roy & Palikhe, 2023). Other challenges include social acceptance and selection of project resources (Roy & Palikhe, 2023).

The reliance on several different types of natural resources as the source of energy means that each requires specific infrastructure to ensure that the process of capturing and conversion of these resources into usable energy must be done effectively and resources can be optimally utilised (TeamHub, 2024). Several stakeholders are involved in RE projects such as governments, regulatory bodies, investors, local communities and project developers and project success is heavily reliant on the cooperation and coordination of these stakeholders (TeamHub, 2024). Additionally, ongoing monitoring and evaluation of the RE projects is key to their longevity. All of the above-mentioned characteristics require careful planning from a project manager (TeamHub, 2024). Renewable energy project management trends

To understand how the efficiency of RE projects can be improved, it is useful to analyse trends in project management in the larger energy sector. Jarosz, et al. (2022) mention in their literature analysis that there is a research gap in the research that summarizes trends in the energy sector in the project management space. There is an indication that there is and has been significant growing interest in sustainable projects in the energy sector. Integrating sustainability into projects can refer to adhering to utilising practices (environmental, ecological, technical, social, and economic) that ensure that the needs of the present are met, while ensuring that the ability of future generations to meet their own needs is not compromised (Jarosz, et al., 2022). Other trends mentioned are the management of knowledge in the post-project phases which include the monitoring and evaluation of established projects and a focus in improved risk management (Jarosz, et al., 2022). Kunya & Yusuf (2023), focus on the relationship between risk management practices and the renewable energy projects in Nairobi and Kenya. Their findings show that 79.6 % of the performance of RE projects of the sample group (67 RE projects and 15 RE companies) are significantly influenced by risk management processes (those used in this study were the processes of risk identification and risk and risk planning).

Jarosz, et al. (2022) also note that a significant reason why there is success in project management in the energy sector is because of learning from the experience of practitioners in the space. Identification of critical success factors specific to particular projects is also mentioned as a trend, because apart from meeting the triple constraints (time, scope, cost) there may be other factors such as stakeholder satisfaction that can be used to define project success (Jarosz, et al., 2022). This is key to making the process repeatable for similar consumer groups.

- **Summary of key features of RE projects**

Renewable energy (RE) projects have several defining features, particularly in terms of environmental considerations, project management challenges and infrastructure requirements. These projects often require large land areas and can significantly impact local fauna and flora. As a result, sustainability is a crucial component of RE project management, ensuring long-term value creation that benefits both the environment and society. Managing RE projects presents unique challenges, including evolving regulatory requirements, complex stakeholder management, long project lifecycles, frequent introduction of emerging technologies, and issues related to social acceptance and project resource selection. The diverse range of natural resources used in RE projects necessitates specific infrastructure for effective energy capture and conversion. Success in these projects depends on the cooperation and coordination of multiple stakeholders, including governments, regulatory bodies, investors, local communities, and project developers. Additionally, continuous monitoring and evaluation are essential to ensure the longevity of RE projects.

Trends in renewable energy project management suggest that there is growing interest in sustainability with an emphasis on integrating environmental, technical, social, and economic considerations into projects. There is also an increasing focus on post-project knowledge management, monitoring, and evaluation, together with improved risk management practices, which can significantly impact project success. Learning from experienced practitioners is another key factor in improving project outcomes. Furthermore, project success is being evaluated beyond the traditional constraints of time, scope, and cost, with stakeholder satisfaction emerging as a critical success factor.

2.2. Successfully Used Project Management Practices and Frameworks in the Renewable Energy Space

There have been several structured project management frameworks and methodologies that have been used for RE projects. A few frameworks that have been used in the RE project management space are as follows:

2.2.1. Project Management Body of Knowledge (PMBOK)

The Project Management Body of Knowledge (PMBOK) approach is a widely used framework consists of five distinct phases shown in Figure 1. The phases are the initiating phase, planning phase, executing phase, monitoring, and controlling phase and finally, the closing phase (Danish, et al., 2019b). A project life cycle generally defines the technical work that will form part of a phase and the people who will be involved in that respective phase (Project Managment Institute, 2000). An illustration of a simple generic project life cycle is shown in **Error! Reference source not found.** showing the relative level of effort r equired from a project team from the start of the project to the end of the project and where the project phases fit in. The practices outlined in the PMBOK can be considered generally accepted most of the time and there is consensus across industries about their value to projects, although uniform application is not implied for all kinds of projects (Project Managment Institute, 2000). The key PM knowledge areas as outlined in the PMBOK that must be considered by PMs to ensure that projects can be successfully planned and executed, are project integration management, project scope management, project schedule management, project cost management, project quality management, project resource management, project communication management, project risk management, project procurement management and project stakeholder management (Project Managment Institute, 2000). The framework as it stands is suitable for small teams on relatively standard projects. When the PMBOK is paired with other detailed methodologies such as the Critical Path Method it could become more valuable (TeamAsana, 2024).

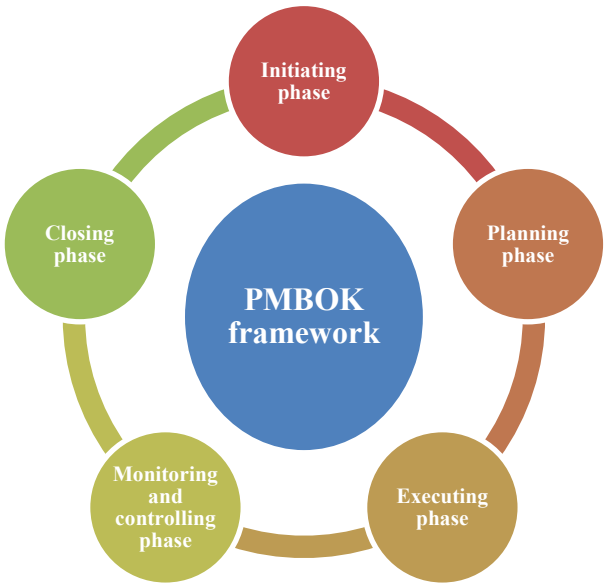

Figure 1: PMBOK framework (Project Managment Institute, 2000, p. 13)

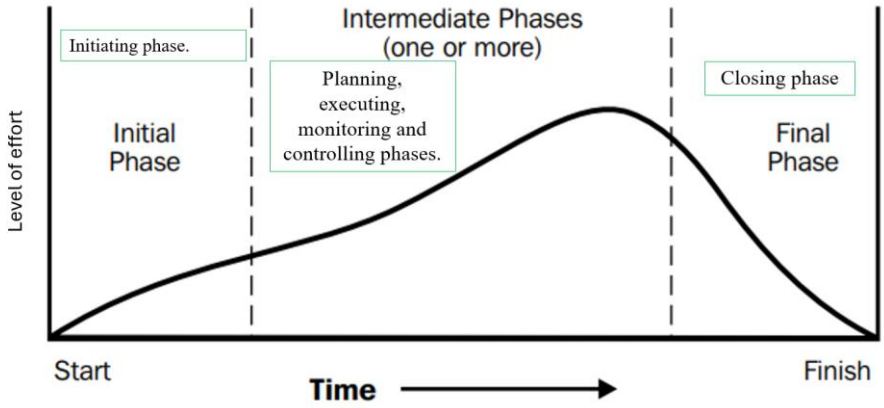

Figure 2:Project Management Life Cycle. (Project Management Institute, 2000, p. 13)

2.2.2. Critical Path Method (CPM)

Critical Path Method (CPM) is a method used where critical tasks are identified and scheduled within a project. It also shows the interrelationships between tasks (Pandey, et al., 2022). The method creates task dependencies, prioritizes deliverables, and tracks project goals, progress and manages due dates. It aims to ensure the milestones and deliverables are correctly mapped. (TeamAsana, 2024) Any delay in a critical task, would increase the overall minimum time it would take to complete the project. CPM is suitable for relatively small to midsized projects. Other benefits of CPM are that it is useful in many stages of a project, provides for slack time (slack time is defined as the leeway in a task has before it delays the overall project timeline (actiTIME, 2024)) in a project, project documentation is provided, and it is useful in cost monitoring (Sri Vidya College of Engineering and Technology, 2021). CPM consists of four (4) steps shown in Figure 3. Limitations are that as the project activities increase, this can greatly increase the number of concurrent or number of activities dependent on other, quickly making it unsuitable for increasingly large projects (Sri Vidya College of Engineering and Technology, 2021).

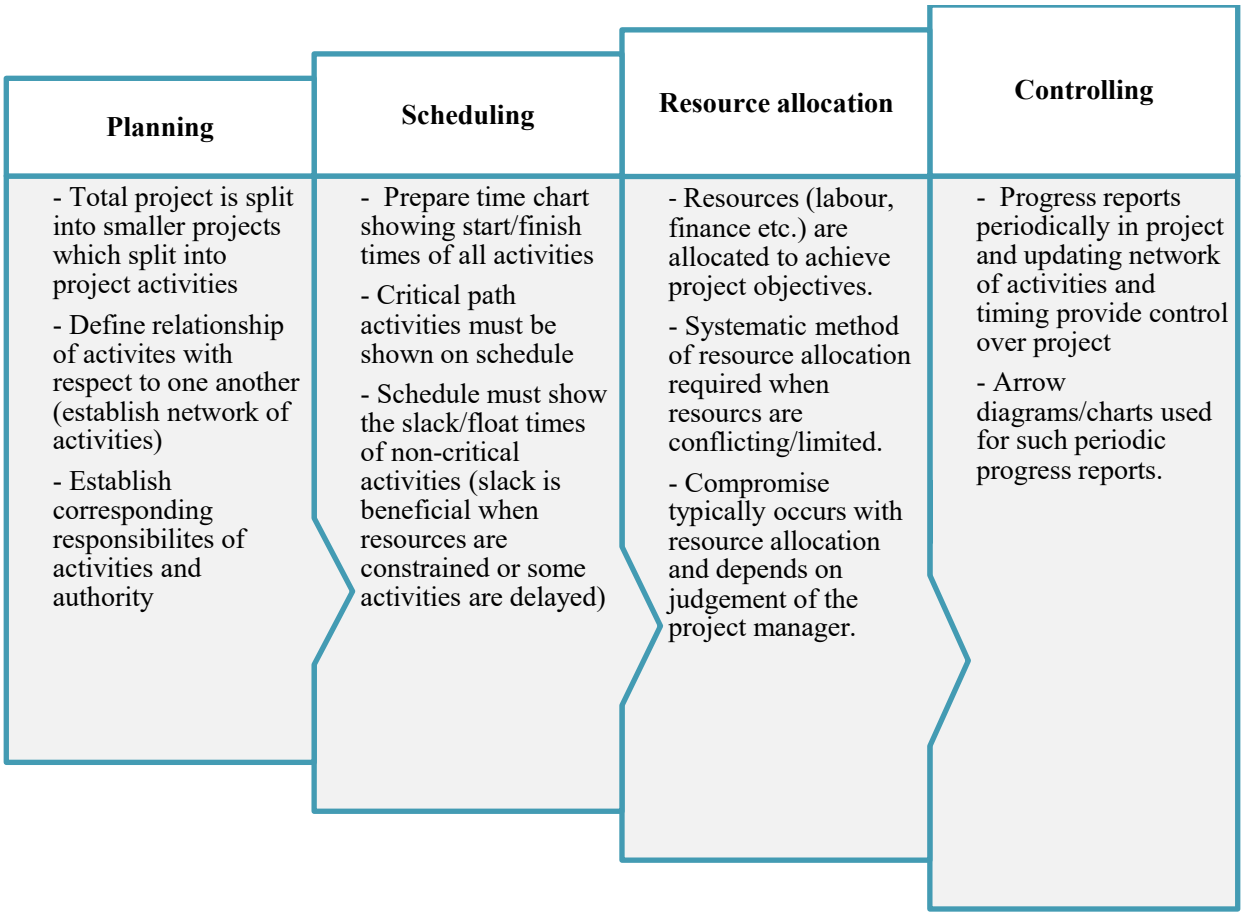

Figure 3: Basic steps in CPM (Sri Vidya College of Engineering and Technology, 2021).

CPM has been used for construction of RE projects. An example as mentioned by Pandey et al. (2022) of the CPM was used to for an Iranian biogas project to estimate the project duration to complete the project which was 38 weeks provided that there were no project delays to postpone project tasks. However, even though it can be used for estimating project durations, several example cases mentioned by Pandey et al. (2022) showed that many fail to meet the completion deadline such as a hydroelectric project named Upper Tamakoshi Hydropower project in Nepal which was delayed by 60 months due to an earthquake.

2.2.3. Project Evaluation and Review Technique (PERT)

PERT is a time-oriented method that is used to determine the time schedule for project activities. It is similar to CPM in that they are both network-oriented techniques except that in CPM the time estimates are deterministic while in PERT the estimates are probabilistic (Sri Vidya College of Engineering and Technology, 2021). PERT has the same basic steps as CPM as shown in Figure 3.The benefits of PERT are similar to that of CPM in terms of cost monitoring, project documentation and providing for slack in the project (Sri Vidya College of Engineering and Technology, 2021). PERT also has the ability to cope

with uncertain completion times of project activities (Lee, et al., 2016). PERT can also be used for construction projects as with CPM.

Lee, et al (2016) presented a project management model for the construction of a renewable energy plant which was a case study for a wind turbine in Taiwan . PERT was applied to determine the critical activities and calculate the total duration and project cost under normal conditions. Two techniques using PERT were analysed which was a discrete PERT method where it was assumed that there was no uncertainty in the time or cost of the project activities. Thus, this makes calculating the cost of activity crashing relatively straightforward. The results for this technique show different project durations, different crashed activities and the associated project costs. A fuzzy PERT method was also proposed where it was assumed that the cost of crashing activities and the penalty cost of not adhering to project timelines are uncertain (Lee, et al., 2016). The goal of this PERT technique was to find an optimal compromise solution between the project cost and project duration. When considering that some activities can be crashed (i.e., allocation of additional resources to project activities) the time duration could be reduced for both PERT methods with the fuzzy PERT technique showing a more optimized solution in terms of cost and time (Lee, et al., 2016). Therefore Lee, et al. (2016) have shown the benefits of PERT for an RE project.

2.2.4. Critical Chain Project Management Method (CCPM)

Critical Chain Project Management (CCPM) is related but is more detailed than CPM. CCPM was developed in 1997 by Dr Eliyahu Goldratt and derived from his earlier Theory of Constraints (TOC). The basic concept of TOC is that there may be at least one constraint at each project stage, and the performance of the project improves when constraint are eliminated completely (Bahnas, et al., 2024). For projects the constraint is the critical path. Buffers intentionally created to make a project resilient against the adverse effects of project delays (Bahnas, et al., 2024). Bahnas et al. (2024) state that there are three types of buffers namely project buffers, feeding buffers and resource buffers. Project buffers are inserted between the last task of the critical path and the date of project completion to ensure that the critical path is not affected by time delays. A feeding buffer is inserted after the last task of the non-critical path/s to ensure that the critical path does not merge with the non-critical paths (Bahnas, et al., 2024). A resource buffer is meant to ensure that there are resources available to the critical path activities when necessary (Bahnas, et al., 2024). A tool used to track project progress is a fever chart shown in Figure 4 (Bahnas, et al., 2024). It shows the project (depicted in blue) progression. The graph is divided into three sections a green region, a yellow region and a red region. The green region means the project is under control, yellow region means the project is under control but there may be a conflict that may cause a delay later on. The red zone the project is not under control and appropriate measures are required to bring the project back to the original schedule. The x-axis

could also represent the percentage of project buffer that is consumed in the project. In the example shown below in Figure 4, the amount of buffer changes as the project reaches completion. This is known as a dynamic buffer. The buffer can be made constant in the project as well. Bahnas et al. (2024) showed through surveys that there was a positive response to the method proposed from construction and engineering professionals in the industry.

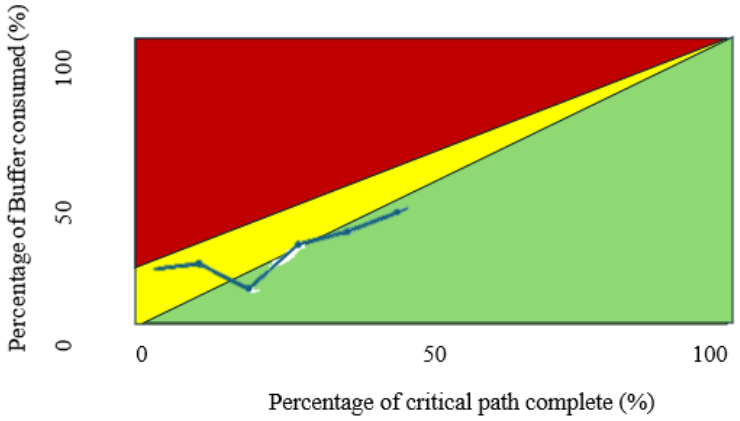

Figure 4: Fever chart. Adapted from (Bahnas et al. 2024)

The time requirements of each critical task in CCPM are specified which improves task tracking (TeamAsana, 2024). Resource levelling is also a feature to ensure resources are not overloaded. It is useful to address project efficiency challenges such as improved reliability/predictability of the project schedule and uses buffer management to assess how buffers of project activities are consumed and need to be replenished (Bahnas, et al., 2024). Proper buffer management is key to CCPM and allows for a clear view of the impact of cumulative risk on the project's performance (Bahnas, et al., 2024). CCPM like CPM and PERT is can also be used for construction projects. Given that time overruns are one of the main challenges with construction projects (Bahnas, et al., 2024), CCPM becomes an even more suitable project management methodology than CPM and PERT. The main challenge in buffer management and monitoring in CCPM schedules is the need to develop effective methods/approaches to monitor and manage buffers in project scheduling (Bahnas, et al., 2024).

Block chain in in CCPM

Bahnas et al. (2024) demonstrate the benefits of using blockchain technology in project management to improve planning and controlling of projects by monitoring buffers in CCPM. Blockchain refers to a distributed database which is shared among several computer network nodes (Bahnas, et al., 2024). Blockchain records information securely, prevents tampering, traceability, process integrity (accuracy and

reliability of project data is maintained) and allows project team members to update progress in real-time without requiring a project coordinator (Bahnas, et al., 2024). Bahnas et al. (2024) validate their findings through empirical observation (recording outcomes before and after blockchain use in project management), comparative analysis of the outcomes, regression analysis that assessed the relationship between blockchain (independent variable) and buffer consumption/project performance (dependent variables) and a comprehensive questionnaire (to obtain insights from professionals with project management experience).

Project Buffer and Resource Management (PBRM) in CCPM

Zohrehvandi, et al. (2020) propose a project buffer and resource management (PBRM) model for project resource levelling and project buffer sizing and control of the consumption of the project buffer in CCPM. This model is applied to a wind power plant project in the Middle East to obtain a more realistic project duration. The methodology follows three main steps. The first step is where resources are levelled resource conflicts are determined. The second step is where the project critical chain is identified, and the project buffer is specified. The last step is where the buffer consumption is monitored and controlled during the implementation of the project. The results show that using the PRBM method the project duration was 75 % (i.e., 113 days) of the original estimate (i.e., 142 days) without the PRBM method. The project duration with the PBRM method was also 29 % shorter compared to the average duration of previous similar projects (average duration of similar projects was 146 days). The applications of CCPM to the construction of RE plants have shown to be beneficial to RE projects and can readily be applied to smaller scale RE microgrids.

2.2.5. Waterfall methodology

Waterfall (considered a traditional methodology) is a method which is sequential in nature. It consists of static phases that are executed one after the other and is the activities are listed out on a Gantt chart (Kissflow, 2024). It is a methodology well suited to projects that have a well-defined, budget, scope estimate, risk is low and where iteration cannot be afforded (Kissflow, 2024). An example of an industry it is used in, is the construction industry and is not well suited to projects where ad-hoc changes occur (Kissflow, 2024). Figure 5 shows the phases which are requirements definition, design, implementation, control, and closure of the project. Advantage of this method are that documentation is extensive, client expectations are clearly set it is relatively easy to understand (Kissflow, 2024). Drawbacks include that changes may be costly and challenging to implement, and problems may be difficult to anticipate (Kissflow, 2024). For renewable energy projects however, the waterfall method can be considered inefficient because RE projects tend to be dynamic in nature (Roy & Palikhe, 2023).

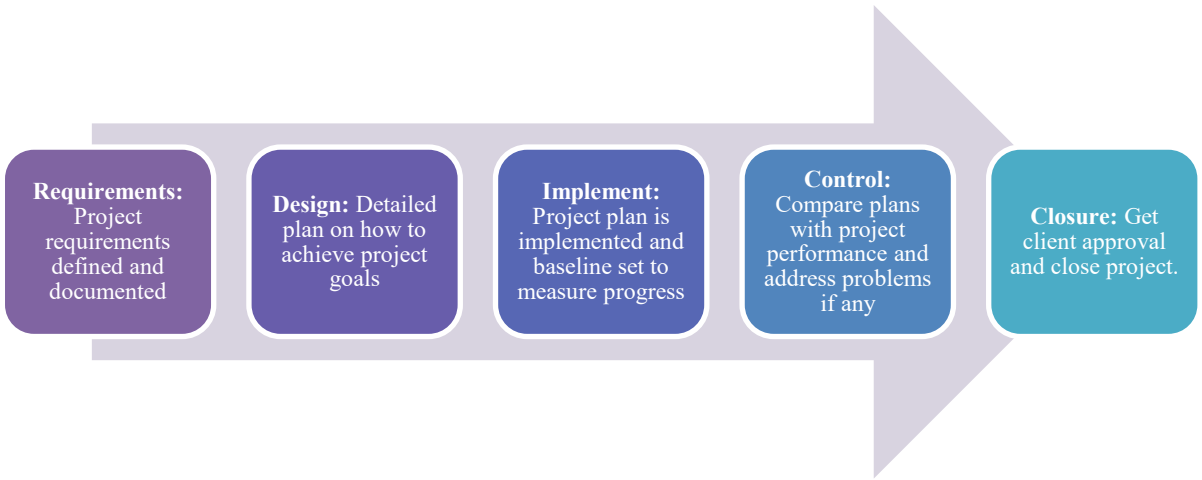

Figure 5: Waterfall methodology phases (Kissflow, 2024)

2.2.6. PRINCE2 methodology

Projects in Controlled Environments (PRINCE2) is a process-based methodology which describes all aspects of project management in a detailed manner by stating how each step looks like, through providing clarity about what is to be delivered in detail and by defining roles and responsibilities precisely (Kissflow, 2024). It has been used for large enterprise level projects (Kissflow, 2024). It is a methodology based on seven principles (Kissflow, 2024):

1. Project viability must be ensured with realistic benefits
2. Learning from previous mistakes and continually update knowledge
3. Roles and responsibilities defined clearly
4. Focus remains on the quality of project deliverables
5. Flexibility to meet the unique requirements of each project
6. Project should be managed in controlled pre-planned stages
7. Authority is delegated based on stakeholder role

Th advantages of PRINCE2 is that it improves team communication internally and with stakeholders, it can be adapted to fit specific project, and it improves accountability since roles and responsibilities are clearly defined (Kissflow, 2024). Drawbacks are that it may be unsuitable for projects where technology is fast changing because there is an emphasis on documentation in the PRINCE2 methodology (Kissflow, 2024).

2.2.7. Agile and Lean methodologies

Adegboyega, et al. (2024) conduct a review on the tools and techniques used within the US renewable energy sector. Findings from the review mention the prominent use of fundamental/traditional project management techniques (Adegboyega, et al., 2024). This includes quantatitive risk management (e.g.,

Monte Carlo simulations and proactive risk plans), stakeholder management techniques, cost, quality and procurement management techniques as outlined in the PMBOK and Gantt charts for project scheduling and monitoring. Even though these tool and techniques have widely been used in the renewable energy secor, their efficacy depends heavily on the context of project and how critical factors are prioritised. Conversely, Roy & Palikhe (2023) discuss how traditional project management techniques may not fully address the dynamic nature of renewable energy projects which could be a contributor to projects having cost overruns and time delays. Several stakeholder groups tend to prefer traditional methods as mentioned by (Roy & Palikhe, 2023), but they also point out that some stakeholders find established project management methods to be time-consuming and restrictive for renewable energy projects.

Renewable energy projects often need adaptive and iterative approaches because of evolving technologies, stakeholder needs changing in the duration of the project, and the pursuit of continuous improvement (Roy & Palikhe, 2023). Roy & Palikhe (2023) propose analysing project management methods not typically used in renewable energy projects, namely Agile and Lean methodology to improve these traditional methods. Agile was initially used more heavily in software industries and Lean in the manufacturing space (Roy & Palikhe, 2023). These methods have a common mindset that places value on collaboration, adaptability, and delivering meaningful outcomes (Roy & Palikhe, 2023). In Agile, an iterative process is followed where one does a 'build-measure-learn' to achieve a minimum viable product while the focus of Lean is continuous improvement follows a 'plan-do-check-act' cycle to improve the quality of products (Roy & Palikhe, 2023).

Roy & Palikhe (2023) discuss an application of Agile in RE projects as tool to achieve effective and collaboration. This assists in identifying errors early, avoid delay and allow for smoother implementation. Specific Agile techniques mentioned are agile iteration planning, agile retrospective meetings and daily stand-up meetings. An application of Lean in RE projects mentioned by (Roy & Palikhe, 2023), is use of Just-In-Time (JIT) method for capacity building. JIT is a process where the focus is elimination of waste and streamlining workflow. Given that JIT places emphasis on using effort only when it is needed, critical project management areas can be identified during the projects and training provided using JIT as required during project implementation (Roy & Palikhe, 2023). Roy & Palikhe (2023) recommend the use of Agile and Lean but do not explicitly cite applications of where their use has been successfully used for RE projects. Adegboyega, et al. (2024) also discuss the application of Agile in the renewable energy projects but cites examples, in Africa and the United States where Agile project management has been applied in smart grid design. Key benefits offered by Agile project management are flexible and responsive adaptation to shifts in project parameters, collaborative stakeholder engagement, continuous improvement and

incremental deployment of smart grid components (this allows for continual testing, feedback and system optimization), rapid prototyping/experimentation, efficient use of resources (reducing waste) and visibility and transparency is enhanced (Adegboyega, et al., 2024).

Taouil, et al.(2014) as cited by Adegboyega, et al. (2024) mention a community coupled microgrid which has leveraged Agile principles to foster close collaboration with local communities, utility providers and technology vendors. This enabled the rapid development and deployment of tailored smart grid solutions that address the requirements and challenges for individual communities and promoted local stakeholder engagement and ownership. For African smart grids, Agile has allowed for solutions to be more suited to the local contexts and overcome barriers to technology adoption (Adegboyega, et al., 2024). This is crucial for rural renewable energy microgrids. In US projects, Agile has assisted in streamlining coordination among several stakeholders including IT systems, end users and utility providers. in larger scale energy projects (Adegboyega, et al., 2024).

Although there have been several benefits for applying different methodologies such as Agile together with or as opposed to the traditional project management methods, consideration must be made for what the barriers may be to fully integrating them into renewable energy projects. Roy & Palikhe (2023) state that the biggest barrier to adopting Agile methods lies in the mindset and organizational culture due to the fact that formality and standardization can be viewed as burdensome.

2.2.8. Summary

Each framework offers unique advantages tailored to specific project sizes, complexities, and requirements. For example, CCPM and PERT are more suitable for dynamic and uncertain projects as described by (ActiveCollab, 2025). PMBOK and PRINCE2 provide structured approaches for standard or large-scale projects by (ActiveCollab, 2025). The Waterfall method, which is popularly used in RE projects, although simpler to use for smaller scale projects, does have limitations, as changes during projects may be costly and challenging to implement and problems may be difficult to anticipate. Although there have been several benefits for applying different methodologies such as Agile together with or as opposed to the traditional project management methods, consideration must be made for what the barriers may be to fully integrating them into renewable energy projects. This section on project management tools and techniques contributes to addressing the research objective that investigates successfully used project management practices in RE microgrid projects and larger scale renewable energy projects. It has demonstrated examples of where these techniques and mentioned the suitability of each of the techniques to a specific type of RE project.

2.3. Challenges in renewable energy project management

Igielski (2023) cite main challenges that occur in project work and obtained inputs from both project managers and project team members that were interviewed in their research. The top three problems, according to the project managers that occurred the most regarding projects was key decision making by main management, too large a scope for projects and a low level of knowledge when it comes to RE project management (Igielski, 2023). The project team members considered the scoping of projects to be the top challenge, followed by low level of knowledge of RE project management and then lack of experience in projects to be the third challenges (Igielski, 2023). From this feedback from the two groups that were interviewed, it is clear that project scope and the level of knowledge around RE project management are prominent challenges that require addressing. With the exception of key decision-making by main management which is not in direct control of a project manager, the other challenges can directly be alleviated by the project manager through measures such as upskilling, and improved scoping for project success. It is noted that a perceived lack of project management skills and project scoping could point to larger systemic organizational challenges such as inadequate PM training or a lack of standardization in the PM methods used.

Beyond PM knowledge gaps, communication plays a fundamental role in addressing project challenges. Igielski (2023) highlights that there are challenges with information flow in projects and Daramola, et al. (2024) expand further on this by discussing the source of some of the communication challenges. These challenges can significantly impact project success. Communication challenges can arise from the complexity of projects, the diversity in stakeholders, understanding how to do proper regulatory compliance and the dynamic nature of the energy sector (Daramola, et al., 2024). The geographical dispersion of rural sites for microgrids makes communication difficult as project teams may not all be in the same time zones, location or the access to reliable communication infrastructure could be limited (Daramola, et al., 2024). N.Zakaria & N.Ahmadian (2019) also makes mention that there is less emphasis placed on communication in the planning phase which is critical to project success. Poor communication plays a significant role in the above-mentioned challenges of project scope as well; if the scope of the project is not discussed and agreed upon clearly with different stakeholder groups, it creates misunderstandings and ultimately scope changes and/or scope creep which impacts the likelihood of project success.

Omole et al. (2024) highlight the successes and challenges in rural electrification. Although the challenges are multifaceted (economic, geographic and/or social challenges), the aspect that project management can more directly address is the social challenges. More specifically, the socio-cultural aspects and community dynamics that strongly influence the acceptance and sustainability of electrification projects. One of the

key aspects of successful projects is effective community engagement. Omole et al. (2024) state that the social dynamics (which includes population density that is typically sparse in rural communities and the attitudes of communities) play an important role in the success of rural electrification. Given that low density communities make it challenging to justify conventional electrification (i.e., connection to the utility grid) from an economic perspective, this means that it becomes crucial for the success of remote electrification that community acceptance and engagement is made one of the main priorities in implementing the project (Omole, et al., 2024). Omole et al. (2024) also state that successful projects tend to demonstrate adaptability to local contexts.

Nombakuse (2019) demonstrates of the views expressed by (Omole, et al., 2024). Nombakuse (2019) highlights an example of a micro-grid where the lack of community engagement proved to hinder the success of the project was a micro-grid located in the Eastern Cape for a village called Lucingweni. Social facilitation was lacking prior to project inception and there was a lack of social cohesion with surrounding communities following the commissioning of the project. This resulted in several occurrences of vandalism and dismantling of the microgrid components. Due to the lack of engagement, the community were unwilling to pay for the cost of electricity, which was more than they could afford, and the system had to stop operation only three months after commissioning (Nombakuse, 2019). This was a clear example of where project management and the project team could have intervened to ensure that the project was tailored to the community which it would serve, and expectations of community members be managed.
Similar findings by Ngubane & Nephawe (2017) investigate the factors that affect rural electrification project management within a South African municipality. Ngubane & Nephawe (2017) are also in alignment with Omole, et al. (2024) and demonstrate a case where a lack of community support has detrimental impacts on the rural electrification infrastructure (i.e., vandalism of equipment occurred). The community was reluctant to pay for levies and rates of the municipalities so this likely points to a lack of stakeholder engagement throughout the project implementation process and getting sufficient community buy-in (Ngubane & Nephawe, 2017). Although (Ngubane & Nephawe, 2017) investigate one specific municipality in South Africa, it is highly likely that many other municipalities and rural communities experience some or all of the challenges mentioned. Hence, knowing how to address these challenges will have a positive effect in realizing more successful projects.

Zakaria & Ahmadian (2019) make mention of the impact of community engagement on projects, however, unlike Ngubane & Nephawe (2017), Nombakuse (2019) and Omole et al. (2024), Zakaria & Ahmadian (Zakaria & Ahmadian, 2019) discuss the community engagement post commissioning of a project. Typically, engagement with the community after commissioning a project becomes minimal, which can

sometimes result in neutrality or hostility towards the project so this must be a considered if a project is going to reach its full useful life. Ikejemba, et al. (2017a) also provide insight into the community engagement aspect after a project ends particularly making mention of public projects that can sometimes be left wanting. Often, the community engagement stops after the project is commissioned with inadequate consideration from the project manager about the ownership responsibilities and management/monitoring going forward. This creates a neutral community position in the community which has resulted in hostility sometimes that ultimately leads to sabotage of the RE project (Ikejemba, et al., 2017a). Ikejemba et al. (2017a) also point out that delegating this responsibly to monitoring or local oversight agencies (who are passive stakeholders) makes the projects more prone to mismanagement. These views may point to potentially formalizing community engagement mechanisms in project planning to ensure that projects reach the end of their useful life. Zakaria & Ahmadian (2019) mention as well that there is a need for improved stakeholder management particularly around issues of delegation of responsibilities. Ikejemba, et al., (2017a) agrees by stating that the stakeholder management and delegation of responsibility, especially following project implementation appears to be one of the more pressing matters that could hinder project success**.**

Soshinskaya et al. (2014), aimed to identify common barriers and factors of success when implementing a microgrid and note that microgrids can vary significantly based on where they are located, their optimization goals and components. This agrees with Omole et al. (2024) in terms of successful projects being suited to local contexts. This means that each microgrid project may experience different challenges. One of the barriers identified regarding the project manager, is managing of stakeholder related challenges which include challenges such as building trust with the local consumers of the microgrid services. Because microgrids are a relatively novel concept for many smaller rural communities creating trust is key to project success (Soshinskaya, et al., 2014). Soshinskaya et al. (2014) used an example of an islanded microgrid in Samsø, Denmark where the PM of the project had challenges with implementation because it took a considerable amount of time to get buy-in from locals. It is clear that the PM and team must have the skills to successfully obtain community buy-in and sell the microgrid vision otherwise the deployment of RE microgrids could be slowed. This is yet another example of why community engagement is key to microgrid success.

In RE microgrid design, there is considerable research that goes into selecting components (both hardware and software) but consideration for its continuous function (especially as the community interacts with it) is not as emphasised particularly for abnormal conditions. For example, for a microgrid deployed in Huatacondo located in Chile, the management of changing consumer habits was challenging. This was

because consumers had to transition from not having light in the evenings before electrification, to gaining access to and having to ensure that they use their power in such a way that they can maintain power through the night (Soshinskaya, et al., 2014). Other factors that adversely affect rural electrification are a lack of strong commitment of project managers on projects and lack of a performance management system/s and benchmarks for monitoring progress by project team members are contributing factors to project failure (Ngubane & Nephawe, 2017). A lack of clear direction/leadership and communication from project managers were also contributing factors to project failure which could be attributed to a lack of experience/competency skills in project managers. The skills deficit in project team members is also a likely contributing factor. Furthermore, another challenge cited was the ability of the project manager to assemble of the project team with suitable technical expertise in rolling out rural electrification (Ngubane & Nephawe, 2017).

Ikejemba et al. (2017a) investigated RE publicly funded projects and pointed out that these projects are seldom successful in Sub-Saharan Africa. Some key project management challenges identified by Ikejemba et al. (2017a) are that project managers are not equipped with adequate skills set and competence to enable them to see projects to successful completion. Skills of project managers can vary, and this can pose a risk given that stakeholder management is a crucial aspect that contributes to the successful implementation of the project. Zakaria & Ahmadian (2019) agree with this fact that the variability of skill levels in project managers can affect project success.

Overall, the recurring challenges mentioned are scope management, communication, stakeholder engagement, and project manager competence. While training, upskilling, and stakeholder involvement are often proposed as solutions, a more fundamental change may also be required in how RE microgrid projects are structured and regulated.

From the literature review the key challenges identified are:

1. Project scoping, team selection, resource allocation, and strategic management. Project managers have limited control over organizational structure and strategic management.
2. Socio-cultural and community dynamics**:** Social challenges, including community engagement and acceptance, are critical in rural electrification projects. Failure to engage with the community can lead to project failure, as seen in the Lucingweni microgrid case where a lack of social cohesion led to vandalism and operation ceased.
3. Adapting to local contexts**:** Successful projects must adapt to local conditions, considering community attitudes and dynamics.

4. Mismanagement, lack of commitment from project managers, and insufficient performance management systems have led to project backlogs and reduced community confidence.
5. Leadership and communication deficits: Lack of clear direction and communication from project managers, often due to inexperience, contributes to project failures.
6. Technical expertise**:** Assembling project teams with adequate technical expertise is a challenge.

These challenges show the need for improved project scoping, upskilling of project managers, better community engagement, and stronger organizational management to ensure the success of RE projects. The research objective this section addresses is identifying key challenges experienced in RE project management practices. The review attempted to examine the potential causes of the challenges mentioned. The review also evaluates real-world cases to that validate the findings mentioned by various authors.

2.4. Identification of successful practices for RE project management

Jarosz, et al. (2022) states that a successful project can be interpreted in terms of project impact success and project management success. Chan, et al. (2004) as cited by (Jarosz, et al., 2022) has a similar view and speaks to critical project success factors which are made up of project factors (procedures, methods, tools), project work processes (which speaks to efficiency) project implementation, human factors and factors that external to an organization. Successful project management is recognized by various sources as a project meeting the scope, cost and time and the project efficiency is described in terms of the satisfaction of the customer (Jarosz, et al., 2022).

Kozhakhmetova, et al. (2019) conducted a study which was a cross-industry evaluation on the effect of critical PM knowledge areas on the project efficiency of green energy projects in Kazakhstan. Project efficiency in this case is defined through the dimensions of cost overrun, schedule overrun and project performance (i.e., adherence to scope). The results from the study show that PM in green energy projects tends to focus heavily on establishing project activities (scoping), developing project schedules and cost estimation. This is consistent with the findings of Igielski (2023) that projects are unlikely to be successful if there are scope management challenges. Less emphasis is placed on risk, quality, and communication planning (Kozhakhmetova, et al., 2019). Project risk is defined as the cumulative effect of the likelihood that uncertain events negatively impact a project's objectives (Petrova, et al., 2019). Project risk management aims to increase the impact and probability of positive events that will contribute to the project and minimize the impact of negative events (Petrova, et al., 2019). Risk, quality and communication are important particularly for RE projects where relatively novel technologies are used. Kozhakhmetova & Anarkhan, (2024) demonstrate the importance and impact of risk management processes (in this case, risk

management processes from PMBOK framework was used) on green projects and identified that statistically, the likelihood of achieving project goals/success, is increased by performing risk analysis. By identifying key PM knowledge and associated planning processes and with the study done by Kozhakhmetova & Anarkhan, (2024) showing the positive impact of risk assessment, this provides valuable insight into what kinds of tools/techniques project managers can use to improve project efficiency.

Petrova et al. (2019) discusses the risk assessment for RE projects. Risk management process is made of five phases namely planning (i.e., determining a decision-making process on how to implement risk management activities), identification of risks, analysis of risks, risk response and finally monitoring and controlling the risks that were identified. Petrova et al. (2019) state that for a project to be successful risk must be dealt with proactively. They go on to demonstrate risk assessment in an RE project where a solar PV plant and small hydropower plant are constructed. Among the risks identified, the risks that can be influenced more directly by the project manager is the communication with stakeholders and risks related to human resources (e.g., insufficient understanding of complex issues related to the plant or frequent changes of the project managers on the project). This shows the importance of risk management in RE projects in agreement with the views of Kozhakhmetova & Anarkhan, (2024).

In terms of the project life cycle, the risk is relatively high at the planning phase but investment in the project is relatively low so the impact of the risk will not be as pronounced. As the project is increasingly realized, the risk decreases gradually because it can better be predicted (Petrova, et al., 2019). Risk has the highest impact however, during the implementation and closing phases of the project life cycle as significant investment has gone into the project (Petrova, et al., 2019). Typically risk identification is an iterative process throughout the project. Commonly used methods for risk identification is interviewing experts, using cause-effect diagrams (these diagrams analyze the root of the risk and the related control strategy) and brainstorming (Petrova, et al., 2019). For relatively simple RE projects, brainstorming is used most often. A risk matrix is a commonly used tool to map the risks of the project (Petrova, et al., 2019).

Solutions proposed for improved management of public RE projects are increased transparency in the project awarding process (involve project managers at the planning stage rather than the implementation stage), strategies for stakeholder cooperation, shared responsibility, and community involvement (Ikejemba, et al., 2017a). Mokan et al. (2019) agrees and mentions that successful RE development is dependent on several critical factors, with specific mention of one of the factors which is about organization and management that consists of strengthening team capacity, client relationships and participation of stakeholders.

2.4.1. Identification of successful practices for RE microgrid project management

Soshinskaya, et al. (2014) observed that at operation stage of a microgrid it is unlikely that the project team deploying the microgrid would be responsible for managing a change in consumer habits to ensure the microgrid can perform optimally. It is thus left to the consumers, who will face challenges without the proper training (Soshinskaya, et al., 2014). In a microgrid in Huatacondo in Chile, this challenge was overcome by holding workshops about the technologies in the microgrids, where the technical interfaces and the energy efficiency plans intended for the community were explained (Soshinskaya, et al., 2014). Another example is a microgrid located in Sendai, Japan where operators were trained on how to handle microgrid operations during natural disasters. This was important since engineering experts are not always available to mitigate such challenges and sufficient education for the microgrid operators, who are likely community members, is an important aspect that needs to be considered by the PM and project team (Soshinskaya, et al., 2014).

Tozzi & Katre (2018) discuss a successfully used community owned model for RE microgrids for remote Indian villages to provide energy access. Apart from the high-quality installations that made model a success, there was emphasis on a close social engagement with communities at throughout the project stages (Tozzi & Katre, 2018). In terms of managing the operations of the microgrids, the governance was also community led with limited external assistance in its operation; this further enforced community ownership. As part of the implementation, local committees with partners such as NGOs and trust who had established links in the communities where the microgrids were implemented had a keen understanding of community needs (Tozzi & Katre, 2018). This is yet another case that highlights the key role that community involvement plays in the success of RE microgrids.

Similar to Tozzi & Katre (2018), Hermawati & Rosaira (2017) identified the criticality of community participation which contributes to RE projects being not only successful, but sustainable in rural Indonesian communities. Hermawati & Rosaira (2017) note factors that contributed to the successful implementation of a microgrid project in a case study of micro wind turbines installed on Sumba Island in Indonesia. These factors were comprehensive project planning and development, local government support and several stakeholders and active participation from the community (Hermawati & Rosaira, 2017). There was also efforts from the project managers to develop capacity building, workshops and creating networks with national and international stakeholders (Hermawati & Rosaira, 2017).

One of the challenges mentioned in section 2.3 by Zakaria & Ahmadian (2019) made mention that community engagement is minimal post project implementation. Hermawati & Rosaira (2017) state that a

likely solution to this is for maintenance scheme, suitable technicians and suppliers are strongly considered as an item to allocate funds towards. Although this suggestion holds promise, it may be limited by funding available.

Given the heavy emphasis that has been placed by several authors mentioned on the importance of community engagement the primary assumption is that the communities would be cooperative/open to being part of the initiatives mentioned. Considerations, however, must be made as discussed by Eklund, et al. (2023), of the social cohesion of community. If the community is fragmented, it could significantly impact the likelihood of success of community engagement (Eklund, et al., 2023).

In summary, from the examples above for RE and RE microgrids successful practices mentioned from several different contexts, it is clear that the project management practices mentioned could benefit the South African context. There are recurring themes from the literature about areas of project management that that are key to the success of projects in RE microgrid space such as stakeholder engagement, risk management, competency of project managers and communication. This section of the literature review contributes to addressing the research objective that investigates successfully used project management practices in RE microgrid projects and larger scale renewable energy projects. The successes mention address the challenge arounds stakeholder engagement by demonstrating that successful microgrid projects require structured, ongoing stakeholder involvement, from planning to post-implementation, to ensure project sustainability. Training and continuous risk management including technical and soft skills mentioned contribute to addressing the project manager competence challenge. For scope management challenges, long term scope, risk and community governance would go a long way in ensuring a project can reach its useful life. Challenges with communication can be mitigated through proactive stakeholder engagement and as mentioned community capacity building.

2.5. Requirements for successful for renewable energy microgrid project management

In this section the requirements for successful RE microgrid project management discussed, including drawing on PM learnings from larger scale RE projects. The findings from the challenges and successes mentioned in sections 2.3 and 2.4 are incorporated as well to compile the requirements. Little (2011) outlines success criteria for successful projects in general shown in Figure 6.

Identifying the business case:	Defining the project:	Project closure
• Ensure that the project fits well with organisational strategy, identify the benefits of project delivery.	- Clarify roles and responsibilities, develop clear objectives including project scope and the success criteria of the project. - Identify and manage stakeholders, define skills required by the project team - Create risk management strategy. - Develop an overall project plan -Define a reporting structure -Define and agree on change managment strategy - Monitor and control the project by periodically comparing actual and planned progress	• Once the closing of the project review the project and compile lessons learnt

Figure 6:General success criteria for successful projects Little (2011)

The success criteria described by (Little, 2011) can be applied to RE projects as a general checklist to ensure that different aspects are covered although it is lacks specificity for the RE sector. In light of this, it is useful to discuss research and case studies that have considered the input of project managers in RE projects and project teams to determine what they consider sector-specific success factors for RE projects. Pandey et al. (2022) reviewed project success factors relevant to RE projects. There does appear to be some alignment with the criteria outlined by Little (2011). From the literature scan, 61 success factors were identified and grouped into nine major categories which are project attributes (e.g., project complexity and project uniqueness, project governance, project strategy, policies and politics, culture and leadership, resources, stakeholder interactions, project parameters (e.g. project cost, scope and time management) and risk management (Pandey, et al., 2022). The category with the highest weighted average score that contributes to project success was project governance which involves factors such as supervision of the project, technological knowledge, efficiency in project procedures, readiness for unexpected disasters and the selected project management methodology chosen (e.g., traditional waterfall project management method) (Pandey, et al., 2022).

There is a limitation of the views of Pandey et al. (2022) however, because the success factors identified are not considered to have the same importance nor do they have the same influence on the outcomes of a project and the results were based on their sample group. Hence, there is need to consistently monitor the success factors and their impacts throughout the project life cycle and potentially, how the success factors interact with one another. Pandey et al. (2022) have demonstrated the value of defining success factors for

RE projects and determining their relative impact on project success, in order to determine problem areas to inform remedial actions. Maqbool, et al. (2020) have a contrasting opinion on RE project success factors. Where Maqbool, et al. (2020) consider the success factors in five categories which are technical, communication, environmental (i.e., external to a project), organizational and team factors, they state that there is a partial reliance of the success factors on the mediating role stakeholder satisfaction plays to achieve project success and have empirically demonstrated this. There is no hierachy of importance in the success factors identified by Maqbool, et al. (2020) as with Pandey et al. (2022) i.e., it assumes that all success factors contribute equally to project success. This can be considered a limitation of these studies. Zaman, et al. (2022) investigated the relationship between critical success factors and sustainable project success in Pakistan. The findings from Zaman, et al. (2022) are similar to Maqbool, et al. (2020) in terms of the success factors they consider to directly contribute to project success, but a key delineation is that Zaman, et al. (2022) identify leadership to be the mediating factor to achieve project success. This difference demonstrates that depending on the country/context, different variables are considered to have a greater impact on the likelihood project success hence the importance of understanding what requirements to prioritize for different local contexts are.

Key general management skills provide a considerable foundation for PM skills (Project Managment Institute, 2000). This includes skills such as finance skills, strategic and operational planning, managing work relations and management of oneself e.g. time management (Project Managment Institute, 2000). Pieterse et al. (2022) investigated critical project management skills required to execute major maintenance projects within the energy sector in the UK. Energy maintenance projects refer to projects where physical assets or facilities that produce energy are maintained periodically to ensure continued efficient and safe operation. Operations and maintenance are significant contributors to the cost of energy project and can typically be 25-30 % of the total project life cycle costs (Pieterse, et al., 2022), hence emphasizing the importance of proper project management of maintenance project and thus the skills that are required by project managers. Key PM skills outlined by the Project Management Institute (PMI) as mentioned by (Pieterse, et al., 2022) are leadership, management, communication, cognitive skills, professionalism and effectiveness. Pieterse et al. (2022) clustered the results for project management skills for energy maintenance projects into seven (7) components in order of observed importance by respondents. These were skills related to:

1. Coordination and scheduling
2. Communication, risk, safety and stakeholder management
3. Quality assurance
4. Managerial skills

5. Forecasting scope and duration of plant outage
6. Time management and implementation skills
7. Technical skills related to plant outage and local site knowledge

The critical skills identified can be applied to RE microgrid development since typically costs are constrained, however it must be noted that this study was conducted in the UK, so its generalizability to different contexts could be limited. If the operation and maintenance costs can be minimized through ensuring project managers are capacitated, then the likelihood that the project will benefit communities for the duration it is intended is higher.

Ndlovu & Weeks (2013) argue for a more balanced approach between soft skills and technical skills as opposed to the more technical oriented skills outlined by Pieterse et al. (2022). Ndlovu & Weeks (2013) identify that there is a lack of a common framework for skills to guide the development of project managers in the energy sector in South Africa. From their research the skill set required includes soft skills i.e., leadership, which forms the basis for interpersonal, conceptual, organizational, problem-solving, negotiation, decision-making, teamwork, behavioural and communication (Ndlovu & Weeks, 2013). Technical/hard skills are included, and integration management is a key driver of project scope, cost, quality, time, risk and procurement management (Ndlovu & Weeks, 2013). The soft skills are more emphasised according to respondants (Ndlovu & Weeks, 2013). Project management qualification/s or certifications were also identified as a benefit but not requirement for project managers from respondants.

The findings from Ndlovu & Weeks (2013) align with that of Zakaria & Ahmadian (2019). Zakaria & Ahmadian (2019) analysed the impact of project management skills on the performance of RE projects through a quantitative study (using a questionnaire from project managers) on palm and oil mills projects. It was identified that three key skills which can be considered soft skills are critical and these were the management of human resources, transformational leadership, and knowledge dissemination (Zakaria & Ahmadian, 2019). From their results, the skill with the highest correlation was human resource management practices particularly related to training. From this work it is evident that not only does the PM need to gain/possess certain competencies to do the job but also be able to positively influence team members. It must be considered however that although Zakaria & Ahmadian (2019) demonstrated empirical support between the skills mentioned and project success, it may not accurately oversimplify the interactions between success factors.

Project scope management was identified as a key challenge in section 2.3. Project scope management aims to ensure that the only the work required to ensure successful completion of projects is included in the scope (Project Managment Institute, 2000). Emmanuel, et al. (2015) discuss strategies for effective scope management in power projects in Nigeria and recommend that because many projects fail due to poor scope management, it is important to define the scope well and this can be done via a detailed work breakdown structure (WBS) at the start of the projects. A WBS groups the scope of a project in a deliverable-oriented manner (Emmanuel, et al., 2015). Key problems identified in scope management is that there are scope creeps and scope changes as mentioned by (Emmanuel, et al., 2015).

Emmanuel, et al. (2015) recommend that there must be mechanisms established for scope review and verification and that robust communication plans with stakeholders can assist in ensuring scope boundaries of projects are respected. Because RE microgrids are relatively novel in South Africa, it may be beneficial to partner with experts in the RE space and draw on learnings from similar projects with comparable WBSs manner (Emmanuel, et al., 2015). This could offer some guidance in managing scope. Lampa, et al. (2017) state that the lack of understanding of the requirement of projects is a hinderance to effect scope management because stakeholders may not be fully aware of their needs at the start of the project. Therefore, this may result in scope changes during the project. It is recommended that a comprehensive needs assessment be done at the start of the project and reviewed as it progresses to account for scope changes. Scope changes may introduce a level of risk (in terms of time and budget), so it is important that together with the needs assessment, risk and change management measures be outlined to account for scope changes.

Stakeholder engagement was mentioned as challenge in section 2.3. Ezeh, et al. (2024) discuss strategies for successful energy projects regarding stakeholder engagement and influence. Identifying, understanding and addressing the interests and concerns of stakeholders (i.e., governments, investors, communities and environmental groups) in projects results in effective stakeholder engagement (Ezeh, et al., 2024).Winch & Bonke (2004) have a similar definition that the successful management of stakeholders involves identifying the stakeholders with their stake in the project, specifying the nature of the stake and assessing the ability to press claim and managing response to the stake so that the impact on the project are minimal.

When stakeholder engagement is proactive, it assists in gaining the required approvals, building trust and minimizing conflicts (Ezeh, et al., 2024). Proactive stakeholder engagement involves transparent process, continuous communication and the active participation of stakeholders in decision-making (Ezeh, et al., 2024). Stakeholders in energy projects can be governments and regulatory bodies that set the regulatory

and legal framework applicable to energy projects and their influence is considered quite significant (Ezeh, et al., 2024). Local communities are also key stakeholders as they are the direct beneficiaries most of the time of RE microgrid projects and directly experience the economic, social and environmental impacts of these projects (Ezeh, et al., 2024). Local communities are also quite influential in that they provide valuable insight into the needs of the communities and the potential impacts on the community – this helps in minimizing resistance from community members (Ezeh, et al., 2024). Other important stakeholders are investors/financial institutions.

Strategies for effective stakeholder management include :

- Stakeholder mapping and analysis which aims to identify relevant stakeholders and involves recognizing all parties who are impacted or have a stake in the project (Ezeh, et al., 2024). Stakeholder mapping illustrates the key stakeholders (ongoing and emergent stakeholders) of a project or organization (Punawani, 2018).
- Early and continuous engagement (such as regular meetings, feedback loops and progress reporting) with stakeholders in the project lifecycle is key in managing expectations and building trust (Ezeh, et al., 2024).
- The development of an effective communication plan which outlines the frequency of communication and methods of communication, channels to be used and key messages to be shared. Information sessions and public consultations can also be useful tools (Ezeh, et al., 2024).
- Leveraging digital tools (online forums, interactive platforms and surveys) to facilitate stakeholder feedback and outreach. This is influenced quite heavily by emerging technologies that can improve engaging with stakeholders (Ezeh, et al., 2024).
- Collaborative approaches to stakeholder engagement such as advisory committees (made of key representatives from different stakeholder groups) and partnerships with local organizations. The benefits of collaborative approaches are the diverse inputs are considered, and it can improve the acceptance of projects for local communities (Ezeh, et al., 2024). Risk management can also be improved by having a larger group of perspectives from stakeholders in identifying and mitigating potential challenges earlier in the project. Partnering with local organisations allows for capacity building and knowledge sharing which can positively contribute to the project longevity (Ezeh, et al., 2024).
- Corporate Responsibility Initiatives – these play a key role in improving stakeholder engagement by companies making efforts to address the environmental and social impacts of the projects they execute. This can be done via ensuring that ethical practices are integrated into business strategies.

Practical examples of CRI are community development programmes such as educational, health facilities and training for locals (Ezeh, et al., 2024).

- Conflict resolution measures in the form of establishing procedures to address grievances during projects or using mediators that are neutral to manage conflict are useful measures (Ezeh, et al., 2024).

Ezeh, et al. (2024) mentioned a case study of successful stakeholder engagement for a wind power project in Kenya. The main challenges experiences was concerns from the local community and the environmental impacts. The developers of the projects addressed the issues by engaging in extensive dialogue with the communities and informing them of the benefits of the project and information about the impacts on the environment. Community development programmes (e.g., building health facilities) were also implemented which improved acceptance and support (Ezeh, et al., 2024). Most of the recommendations are suitable for application to rural RE microgrids, however, the recommendation that may be a limited is the use of digital tools. For the project team and stakeholders with access to technological resources, interacting via digital tools is relatively easy, but for the local stakeholders, the approach may need to be tailored to manage them e.g., if surveys are to be collected, physical surveys may be more suitable than online surveys.

Human resource management was identified to be challenge. Human resource management is inclusive of processes required to make the most effective use of the resources in the project (Project Managment Institute, 2000). Eleogu, et al. (2023) discuss the critical role human resource practices play in the energy sector. The human resource practices in an organization can be a strategic tool to improve the skills in the renewable energy sector through tools such as capacity building for project team members (Eleogu, et al., 2023). This is important to microgrid projects. Skills mapping at the start of projects recommended to gain an overview of the required skills for projects to ensure that all the required skills are available to successfully complete the project. From the feedback in the first set of interviews, the use of local resources in projects was emphasized, which aims to enhance community ownership. It was also mentioned that that a resource plan with resource levelling is recommended as this is beneficial in ensuring the project resources are not over or underutilized.

Communication was identified as a challenge. Daramola, et al. (2024) explores use of digital tools and Agile practices in enhancing communication efficiency by having a significant impact on streamlining communication. Daramola, et al. (2024) states that integrating Agile practices and digital tools can play an important role in contributing to project success in the energy sector. Several factors influence

communication efficiency in projects such as leadership style, organizational culture, channels of communication, adoption of technology and the complexity of projects (Daramola, et al., 2024).

Digital tools like collaboration platforms, various project management software and information systems are ways in which real time communication and sharing of information can be achieved with various stakeholders (Daramola, et al., 2024). This can be used to track project progress, manage documentation and improve decision making (Daramola, et al., 2024). It must be noted that digital communication may, for most rural microgrid projects, be limited to the project team and stakeholders that have access/are comfortable with technology usage. Soliciting feedback from local communities may prove challenging only using digital means. It is therefore recommended to gauge the proficiency with technology of stakeholder groups and if it is not adequate for the desired data collection by the project team then more traditional methods (like physical data collection for surveys) be used when getting feedback. Agile places emphasis on flexibility, iterative development and adaptive planning. Kanban, Lean and Scrum are Agile methodologies that encourage stakeholder engagement, continuous improvement and frequent communication which can improve productivity and the quality of project execution (Daramola, et al., 2024). These are not yet widely used in RE microgrid projects, but there may be benefits of applying them to improve communication. Project teams can use standard templated for reporting, updating and documentation throughout out the project and these must be developed the relevant stakeholders to ensure alignment.

Risk management was identified as a challenge. The major process in risk management include risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning and risk monitoring and control (Project Managment Institute, 2000). Recommendations for improved risk management include:

- Risk response plans for proactive risk management (Adegboyega, et al., 2024)
- Risk registers or SWOT analysis
- Probability impact matrixes - this is a matrix that assigns risk ratings to identified risks and an impact scale that reflects how severe the effect of a risk is. (Project Managment Institute, 2000)
- Developing good relationships with local and international suppliers as projects are done to ensure sourcing is diversified (Adegboyega, et al., 2024). One must note that most of the time one only gains a better understanding of the procurement management once when one engages suppliers.
- Implementing robust inventory management systems to mitigate supply chain risks (the RE industry is vulnerable to disruption for supply for components like solar and wind turbine blades)

(Adegboyega, et al., 2024). This is especially relevant with countries where there may be unfavourable conditions (such as conflicts) which would affect supply chains.

Rajpurohit & Jain (2023) state that the renewable energy sector is one of the industries most affected by rapid changes due to the global economic, social, political and technological environment. This is because the RE industry involves policy, technology and market factors that impact governments, society and businesses significantly (Rajpurohit & Jain, 2023)**.** Thus, to ensure organizations can continue to be effect and sustainable, they must have measures in place to be able to adapt to the changes in the RE industry hence the importance of change management. Key challenges that organisations experience in the RE sector due to the changes it brings are loss of resources and profit, resistance, dissatisfaction and insufficient awareness of the significance of strategic change and adaptability in the organization (Rajpurohit & Jain, 2023). In light of the challenges mentioned above, Rajpurohit & Jain, (2023) highlighted that training and development and leadership support contribute significantly to talent and change management which means that change management must be affected at more of an organizational level rather than just for project level. Odulaja, et al. (2023) agree with this, in their research where they discuss the role HR plays driving and managing organisational change by equipping employees with the required capacity building to adapt to the regulatory and technological shifts in the RE industry in Nigeria. It is also mentioned that HR plays a role in fostering resilience and innovation which is key in retaining employees and maintaining morale through periods where change is experienced.

From the various literature, the requirements for successful RE project management for microgrids are:

- **Identifying the business case:** Align the project with organizational strategy, clearly identify benefits, and ensure costs justify the project.
- **Clear project definition** :
    - Clarify roles, responsibilities, objectives, and scope
    - Identify and manage stakeholders and required skills.
    - Develop a risk management strategy and an overall project plan with clear reporting structures.
    - Monitor and control project progress.
- **Closing the Project**: Review and document lessons learned at project closure.
- **Proper selection of project team members**
- **Sufficient and suitable resources/tools availability**: This is essential for execution.
- **Project manager assignment/managerial skills**: This is important for the project to be executed
- **Proper project planning**: Critical for ensuring smooth project progress.

- **Information flow**: Ensures clear communication and project alignment.
- **Strategic management**: Includes both project and organizational strategy alignment.
- **Cooperation with implementation institutions**: Important for compliance and support.
- **Project governance**: Supervision, technological knowledge, efficiency, and readiness for unexpected events.
- **Culture and leadership**: Impacts the project execution.
- **Project parameters**: Cost, scope, and time management
- **Quality assurance:** Ensures project standards are met.
- **Technical skills:** Specific to project needs, particularly in maintenance including end-user training to ensure the microgrid can be utilised as intended.

In summary, given the different perspectives, it is clear that a 'one-size-fits-all' approach to RE microgrid project management is inadequate. Instead, an integrated guidelines that combines technical governance (as highlighted by Pandey et al. (2022), stakeholder engagement Maqbool et al. (2020), and leadership adaptability Zaman et al. (2022) would be more effective. For RE microgrid projects, where financial constraints and community buy-in are critical, a combined approach that prioritizes both technical execution and stakeholder satisfaction may result in better project outcomes. Future research should focus on refining this balance and assessing which factors hold the most weight in different microgrid deployment contexts. This section of the literature review has addressed part of the second research objective which was determining the requirements for project management for successful RE deployment. Key success factors were identified, starting with examining general success criteria that can be considered, then further introducing sector specific success criteria which have shown to be non-uniform across different contexts (especially given that RE microgrids may prioritize different factors). Key skills were also identified as part of the requirements.

2.6. Conceptual framework - A priori theme development

The literature review provides insight into the project management challenges, successes and requirements of RE microgrid deployment. From this, themes can be developed from the literature which inform the subsequent direction of the content of the qualitative data collected. The type of themes formulated from the theoretical understanding of the phenomena that is being studied are called *a priori* themes (Bernard, et al., 2016). The *a priori* themes are developed from extracting codes from the literature review and using the codes to form the themes. The codes are contained in Appendix B. Figure 7 shows the themes developed. The main themes are project management skills, culture, project management tools and techniques, leadership and project success criteria. For PM tools and techniques to be effective, a project

manager must have the ability to use them well, hence the link to PM skills. Under PM skills, are subthemes which are risk management, project planning, project closure, time management, financial management, stakeholder management, scope management, communication and adapting solutions to local contexts. These are all skills that a project manager must be able to demonstrate to result in project success. Under leadership the subthemes identified are to do with project team selection and project team skills – factors which can be improved if leadership is strong. Project team skills has technical skills which was identified. This too can be improved with leadership support in terms of accessing capacity building. Project success criteria has the subthemes of project performance measures and monitoring control measures. Project success criteria provide a structured ways to ensure projects meet their objectives, stays on track and expected outcomes are delivered.

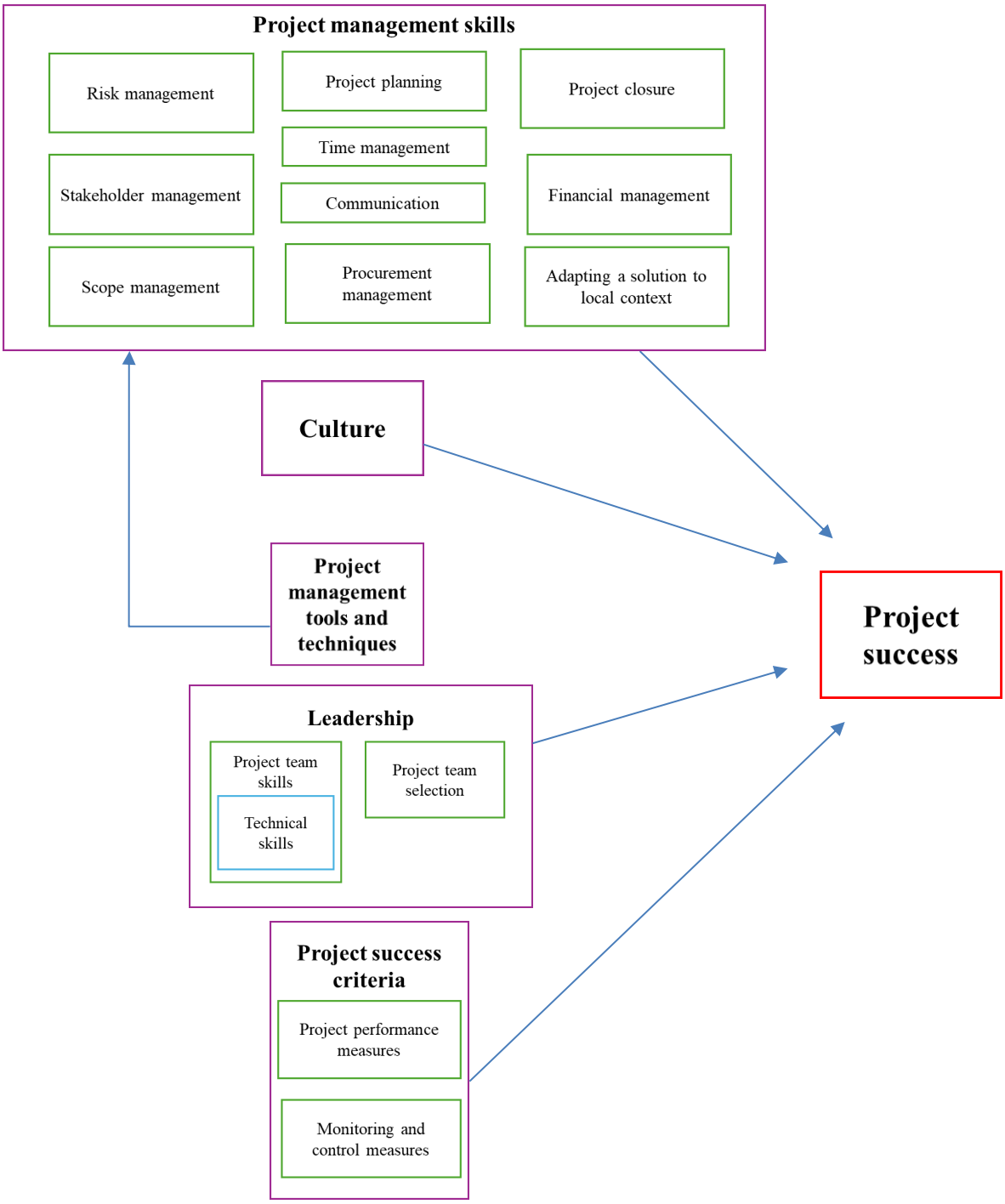

Figure 7:A priori themes

CHAPTER 3

RESEARCH METHODS

3.1. Research Design

The type of study that was done for this research was a qualitative, phenomenological study, which describes the meaning for a group of individuals of their lived experiences from a phenomenon (Creswell, 2007). Addressing the research objectives was based on a literature review and the collection of qualitative data. The literature review provides a wider view of the project management practices that have been successful and the project management knowledge areas that require improvement. The type of qualitative data was through semi-structured interviews with experts in the RE space that have project management experience in South African RE projects as well as particular focus on microgrid deployment experience. The results for the research were derived from transcription of online interviews with several experts in the RE space who provided review and inputs on compiled requirements for successful deployment of RE microgrids in South Africa. Apart from using a literature review to conduct the gap analysis, the interviewees provided insights from their experience about important project management gaps and challenges in South Africa. The input into the requirements for successful deployment of RE microgrids and the gaps and challenges in RE PM in South Africa formed part of the first set of interviews. The second set of interviews was a follow up to seek out review and input from interviewees about the recommendations for standardized PM practices for RE microgrids. This also included the recommendations on addressing the gaps in PM for RE microgrids. Figure 8 shows a detailed map of the research process.

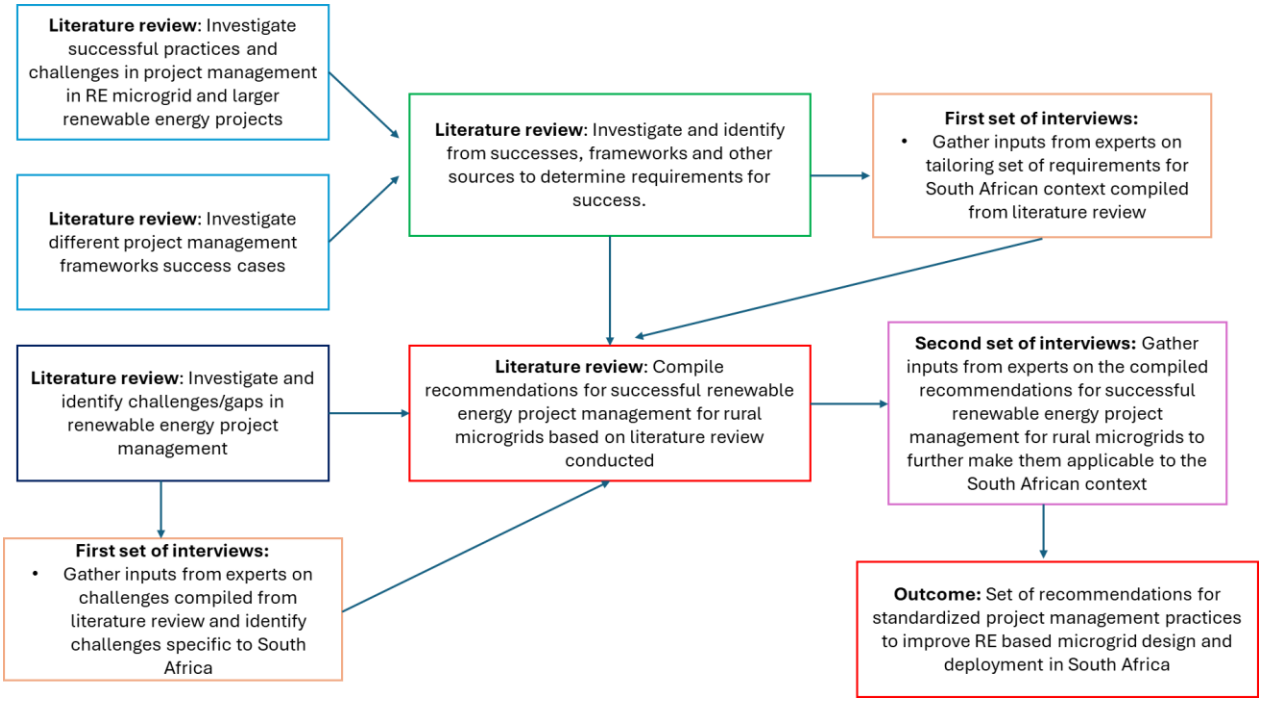

Figure 8: Detailed map of research process

3.2. Instrumentation

The instrument used for research objectives 2 and 3 was semi-structured interviews. Interviews are conversions but they involve understandings and a set of assumptions about the situation which is not present in casual conversions (Wilkinson & Birmingham, 2003). The questions were derived from the literature and the preliminary conceptual framework. Figure 9 shows the CRQ-TQ-IQ pyramid model by Wengraf (2001) which illustrates how a methodology to formulate interview questions (IQ) which are informed by theoretical questions (TQ) that are ultimately tied to the critical research question (CRQ) that attempts to fulfill the research purpose. Some examples of the questions are shown in Figure 9The full set of interview questions can be viewed in Appendix A.

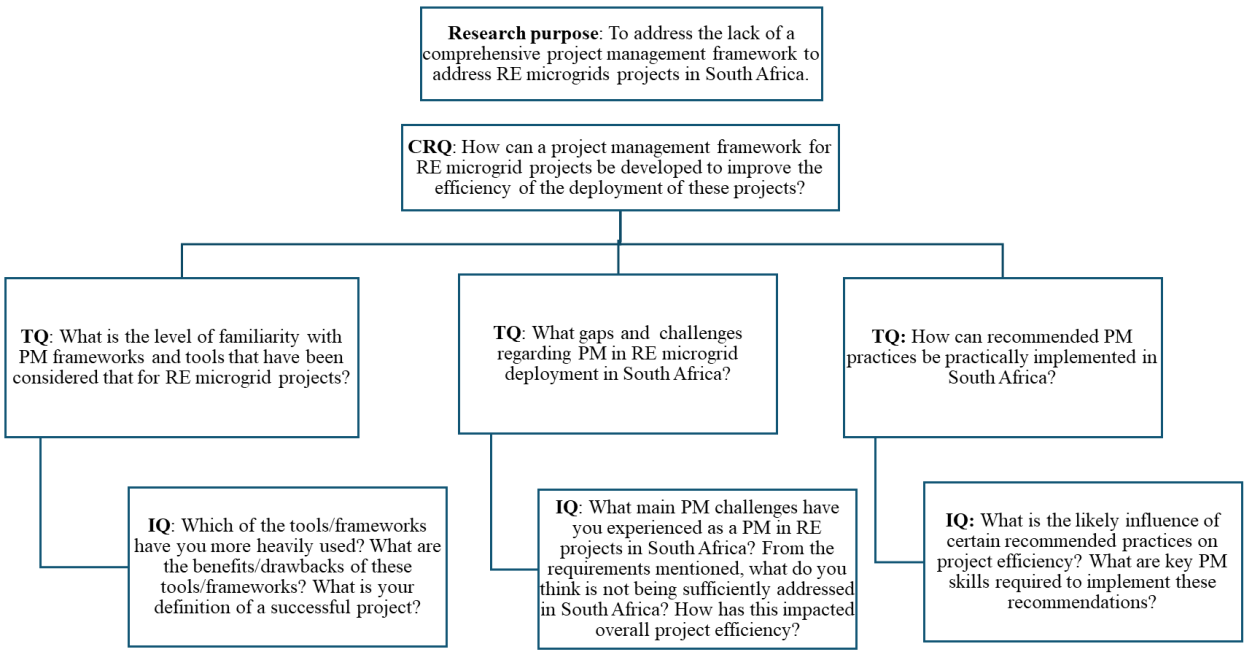

Figure 9: CRQ-> TQ->IQ Pyramid model

3.2.1. First set of interviews

- **Part A: Familiarity and use of project management frameworks and tools used for renewable energy projects and RE microgrid projects**

The significance of question 1 was to determine tools used for project management of RE and RE microgrid projects and whether more traditional or alternative methods have and are being used in the energy space. Question 2 focussed on gauging what is practically used and benefits/drawbacks of the tools mentioned. Question 3 was about finding out project management style/approaches used by participants. This aids in identifying common styles among project managers in the renewable energy space that could inform how to tailor approach for South Africa. Question 4 – Question 6 are related to finding out how the parameters of success, project performance and project efficiency are defined by participants because this provides guidance into the factors that can contribute to/be controlled to increase the likelihood of that RE microgrid projects have a more standard definition of how to define these three parameters to make the process more repeatable. Question 7 sought to identify the key skills project managers require in South Africa in the energy sector that will contribute to successful RE microgrid projects. This also assisted in determining a more standardised template for required skills in South Africa. Question 8 is where input was solicited from the participants around the requirements that had been compiled from the literature review as shown in Table 2 in Appendix A. In question 8, a ranking exercise was undertaken with the aim of ranking the requirements outlined for successful execution of a RE microgrid project from the most important requirement to the least important in relation to South Africa – this provided insight into where more effort

must be put forth by project managers to ensure that higher impact requirements on project success are afforded the appropriate time and budget relative to other requirements. Knowing how the requirements are ranked also provided information as to which factors have a larger impact on project efficiency as well.

- **Part B - Challenges regarding project management in renewable energy microgrid deployment in South Africa**

Question 1 in Part B focused on identifying specific challenges in the project management lifecycle to identify where in the project certain challenges arise. Question 2 referred to the requirements mentioned in Part A to understand which requirements are not being fully addressed in South Africa with the goal of determining where more effort is required for project managers. Question 3 focused on finding out if participants have had any involvement the process of monitoring deployments after they have been commissioned and if project managers have played a role. This is important given that a rural microgrid is planned for at least 15-20 years of operation and its longevity is a crucial part in determining whether it is a success in its entirety or not. Question 4 seeks to find out skills that are missing in the South African context from the views of the participants. This can assist companies in informing where and what capacity building may more immediately improve microgrid project efficiency. Question 5 sought to establish if there are challenges specific to South Africa that may not have been mentioned in previous sections or from the unique experiences of the experts interviewed. In question 6, a ranking exercise was undertaken with the aim of ranking challenges RE microgrid project currently encounter and may face in South Africa from the most pressing challenge to the least pressing challenge. This provided insight into challenges that must be prioritised by project managers to ensure that those with a greater impact on project success are mitigated and managed accordingly and the appropriate effort is expended for this purpose.

3.2.2. Second set of interviews: Recommended project management practices to be practically implemented in South Africa

The purpose of the questions in the second set of interviews was to gauge the applicability and consider practicalities of implementing the proposed recommendations and tailor them for the South African context. The questions are contained in Appendix A. Question 1 focused on identifying from the established themes, which would impact project efficiency and the most. The aim of this question was to assist in determining where efforts should be prioritized for towards recommendations under that selected themes to improve project efficiency. Question 2 aimed at establishing if the proposed recommendations are suitable to implement in South Africa and the practicalities that must be considered. Question 3 sought to find out if there are any barriers that may stand in the way of implementing the proposed recommendations.

3.3. Sampling

The type of sampling that was used is purposeful sampling because it is suited to individuals who understand the main phenomenon of the study (Creswell, 2007). These were individuals who have varying degrees of project management experience in RE microgrid design and deployment (the phenomenon in this case) and other renewable energy projects in the RE space in South Africa. It is ideal to select experts from different disciplines within the energy sector given that microgrid design and deployment involves several different aspects. For example, a senior grid studies engineer and an engineer that works in energy modelling are useful participants for the study.

The characteristics of the sample group were that they would need to be at least at a senior level, because project managers for RE projects are meant to be able to lead a team and for most organizations this would be an individual at a senior level. The sample group did not necessarily have to be a specific gender, but a relatively balanced group 50/50 of women and men if possible was desirable to avoid gender bias. Polkinghorne (1989) as cited in (Creswell, 2007, pp. 57-62) states that when selecting the sample size for interviews, researchers select between 5-25 individuals who have experienced the phenomenon. To select a suitable number of interviews, the point at which data saturation occurs must be considered. This is a technique that is typically used to estimate sample sizes in qualitative research. Data saturation is the point in the research at which additional data collected provides little to no information to address the research question. Guest et al. (2006) as cited in (Bekele & Ago, 2022) states that for a research project that uses purposeful sampling 6-12 interviews would be sufficient. For this research, 8 individuals were selected.

3.4. Data Collection

The data for the semi-structured interviews was collected via an online medium that were recorded and transcribed. A consent form, proof of ethics clearance (ethics clearance number MIAEC 021/24) and a participant information sheet that summarized the research was shared prior to conducting the interviews. The research proposal was shared upon request. To participate in the interviews the participants were required to sign a consent form giving permission to use their input for the research and be recorded. The interviews took place with participants within the period August 2024 –January 2025. The first set of interviews took approximately 30-45 minutes per participant to complete, and the second set of interviews was approximately 30 minutes in length per participant.

3.5. Data Analysis

Once the interviews were transcribed, coding was used to begin to analyze the data. Coding refers to the process of assigning an attribute that captures a summative or particular essence for a portion of the data (Saldaña, 2015). This assignment segments the data into units called codes. Creswell (2007) states that codes can originate from a number of sources such as exact words used by participants or code names that are drawn from a particular field (e.g. health sciences) or names that a researcher chooses that appropriately describes the information collected. Codes can be representative of information that is unusual, conceptually interesting, surprising or information that was expected to be found prior to a study (Creswell, 2007). The codes generated are contained in Appendix B.

Thematic analysis was used for analyzing the data from the codes. Thematic analysis is suitable because it is a method that is used to identify, analyze, and interpret themes within qualitative data (Braun & Clarke, 2006). The themes capture important details about data related to the critical research question/s and it is expected that patterned responses results from the analysis (Braun & Clarke, 2006). Theoretical thematic analysis was suitable for this research as it is a 'top down' approach tending to be driven by a researcher's theoretical interest in a particular topic (Braun & Clarke, 2006). In this case, the theoretical area of interest is project management for RE microgrids. The first set of interviews was intended to solicit inputs about the requirements for successful deployment of RE microgrids from experts in in the RE space and contribute to identifying gaps in PM in the South African context. The input from different interviewees was organized thematically because the ultimate goal of the research is to establish common practices PM that are suited to South African RE microgrid projects. From the themes established, recommendations were compiled, were used for the second set of follow-up interviews to get input for implementation for the South African context. Figure 10 shows an overview of the data analysis process.

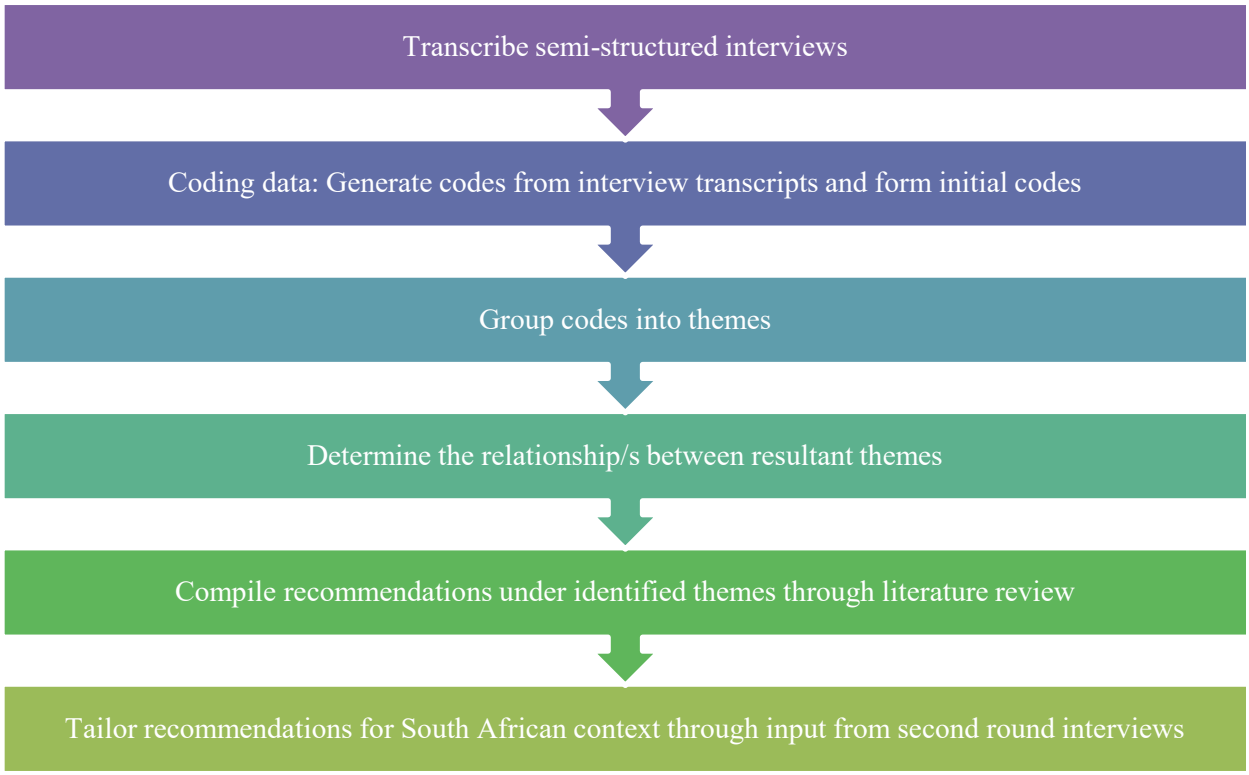

Figure 10: Data analysis process (Braun & Clarke, 2006).

3.6. Validity and Reliability

Qualitative research relies on naturalistic inquiry and can be challenging as the structure of research can be diverse depending on the topic of research. A researcher is the primary collector and interpreter of the data and therefore, rigor must be applied to the research process (Cypress, 2017) . Rigor is defined as the quality of being accurate and thorough (Cypress, 2017). Rigor equates to reliability and validity (Cypress, 2017), which are two aspects that form part of all research and are necessary to ensure appropriate quality of research. Reliability refers to the care and consistency applied to research practices which are reflected in the results, analysis and conclusions of the research while noting the limits of the research findings (Cypress, 2017). Validity refers to the quality of the research being just and sound for the purpose it is intended for (Cypress, 2017). For this research, a record was kept of the process from coding the interview transcripts and interpretations from these transcripts to ensure the reliability and validity of the process.

Content validity refers to the degree that a research instrument (in this case the semi-structured interviews) covers the content that it is meant to measure (Yaghmaie, 2003). Burns & Grove (1993) as cited in Yaghmaie (2003) states that content validity can be obtained from three sources namely literature, individuals who represent the relevant population/s and experts. For this research, content validity was obtained from the literature review and expert input. The expert input to validate the content was through

criteria for measuring content validity which are evaluating the relevance, clarity, simplicity, and ambiguity of interview questions (Yaghmaie, 2003). The pilot interview with the first participant was conducted and at the end of the first interview with them, feedback was requested from them to validate the content for the subsequent interviews. From the first interview, the questions with the detailed answers from participant 1 that were asked regarding content validation can be viewed in Appendix A.

CHAPTER 4

RESULTS

This section contains the results from the first set of interviews, followed by the identification of themes, recommendations and subsequently the results from the second set of interviews.

4.1. Participant profile

Table 1 shows the criteria used to select participants. The gender is balanced (50/50) between men and women. All of the participants are at least at a senior level as intended. Most of the project management experience was gained on the job for the participants and very few have formal qualifications. This shows that although qualifications are beneficial to the execution of projects, they are not considered a requirement to execute RE and RE microgrid projects from the sample group that was interviewed.

Table 1:Criteria used for selection of participants

Research participant	**Gender**	**Position role in energy sector**	**Reason for selection of participant: Degree of project management experience in RE projects and RE microgrid projects**
Participant 1	Female	Senior researcher in energy modelling	• Project management experience has included mostly learning on the job and short courses. • No formal PM qualifications.
Participant 2	Female	A senior researcher whose work focuses on the Just Energy Transition (JET) and Energy Industry	• Manages various energy research projects as a senior researcher • No formal PM qualifications.
Participant 3	Male	Head of technical division of procurement of renewable resources	• Project management diploma • On the job experience with project management
Participant 4	Male	A senior researcher in power system design, power systems and planning	• No formal PM qualifications. • Short courses – fundamentals of project management and use of PMBOK • Work experience with managing construction of microgrid commissioning

Participant 5	Male	Senior researcher in power grid studies	• No formal PM qualifications. • On the job experience with project management (~ 19 years' experience)
Participant 6	Female	A senior researcher in the Energy Industry with focus on socioeconomics of the JET	• No formal PM qualifications. • On the job experience with project management
Participant 7	Female	A senior energy expert whose work focuses on advocacy for JET.	• No formal PM qualifications. • Short courses – fundamentals of project management • On the job experience with project management
Participant 8	Male	A senior electrical engineer with experience in energy research (heavy current)	• No formal PM qualifications. • On the job experience with project management

4.2. Development of themes

4.2.1. Part A - Familiarity and use of project management frameworks and tools used for renewable energy projects and RE microgrid projects

Theme 1 : Preferred project management tools and techniques

From Table B4, Appendix B, question 1 and question 2 are grouped together. Question 1 sought to find out what the preferred project management tools and techniques are according to the participant feedback, while question 2 sought to find out what the benefits and drawbacks are to determine why certain tools are used more often over others. This provides insight into the advantages of using certain tools and techniques and understanding the drawbacks, while providing insights into other tools or processes that may increase the efficacy of the tools currently used or replace them all together. Hence, from the *a priori* themes identified from the literature review, question 1 and question 2 fall under project management tools and techniques. Participant 1, participant 5 and participant 8 mentioned that the Waterfall method was a preferred method used. Participant 1 mentioned that the benefits of the Waterfall method are that it has provides a reasonable amount of control in managing a project and can prioritize activities. However, the drawback of the Waterfall method is that time and cost overruns, resources constraints and levelling resources cannot be managed well. Participant 5 also considers that the Waterfall method is sufficient particularly for RE microgrids and that other more complex project management tools/frameworks can be considered

'overkill'. No drawbacks were mentioned by participant 5. Participant 8 identified that the benefit of the Waterfall method in their specific company is that it provides clear direction for financing committees where approvals are required and ensures that there is sufficient budget to account for required resources. Participant 8 however stated that in projects with a research element, this PM method can cause several delays (similar to participant 1) and that it can sometimes be in conflict with their company processes. Participant 1, 5 and 8 did not however make specific mention of the software tools used when using the Waterfall method.

Participant 2 and participant 4 identified PMBOK as their preferred PM framework used. Benefits of PMBOK identified by participant 2 are that it is an internationally recognised framework that introduces a level of standardisation. It makes it easier to communicate, it creates room to address project specific requirements, it allows a level of flexibility in one's implementation and it emphasizes the importance of risk management. The drawbacks mentioned by participant 2 are that PMBOK can be considered complex for new project managers, and its use alone can potentially overshadow the importance of team dynamics and interpersonal skills required by project managers. The benefits identified by participant 4 are that PMBOK offers a wholistic understanding of different aspects of a project, provides good coverage of what the PM process entails however, the drawback are that it is quite lengthy and comprehensive and that for low complexity projects, PMBOK can be a bit exhaustive.

Participant 3 identified tools used to be Microsoft Project most often and their own customized PM tool using Microsoft Excel as and when needed. They mentioned that the Critical Path method was a preferred method. Benefits of the CPM is that it is useful to track resources and mitigate risks. Benefits of Microsoft Project (especially with the CPM) is that it allows one to minimize errors, think critically about each task and gives a good overview of projects. Limitation/drawbacks of Microsoft project is that considerable time may be required to be invested upfront to properly plan the project and if there is limited or no consultation with project teams, the tool may be ineffective. Participant 6 and 7 also mentioned the frequent use of Microsoft Excel given that it is relatively easy to work with. Participant 7 stated further that it offers good visualization of what will be done in a project. The drawbacks, however, according to participant 6, are that it does not reflect the parts of the project not within one's control well and participant 7 said that the in-built Excel functionality (e.g., macros) cannot optimize resource loading. Both of these participants mentioned other company specific tools (SAP Plant Maintenance for example - this is a software used for industrial companies where the key tasks of maintenance and management of technical systems can be monitored) that are used as well but less frequently.

Overall, from the sample group, the Waterfall method was mentioned as the most frequently used method and the tool that is most often used is Microsoft Excel. The rationale for the use of these appears to largely be owing to their simplicity, particularly for smaller scale RE projects, although there are drawback in functionality in some instances. This shows that there is room to consider supplementing the functionality to overcome these drawbacks. It is evident that companies, in more than one instance, based on the feedback, require of their employees to make use of company specific tools/methods and that misalignment with company process impacts the efficacy of the use of certain methods/tools.

Themes 2 : Project management style and skills

From Table B5, Appendix B , question 3 sought to determine the extent of collaboration when participants manage projects with their project teams, and ultimately, sought to establish if there is commonality in project managers' style in the management of RE projects. Participant 1, participant 2, participant 3, participant 5 and participant 7 share commonality in that they emphasise collaboration with team members in the management of the project from the conceptualization stage. There was consensus among this group that the project schedules should be jointly developed. Participant 1 went into more detail by stating that their style may be modified, however, when involving team members in planning, based on the number of resources available to the project i.e. with fewer resources, their style becomes more authoritative (i.e., they involve project team members less than if there were more resources). Participant 3 detailed that not only should team members be involved from the beginning, but further that since RE microgrid projects tend to have multiple disciplines e.g. electrical, mechanical and geotechnical professionals to name a few, these stakeholders too must be involved in building project milestones from the beginning and build project schedules jointly. This makes it easier to identify risks and mitigate them accordingly. Participant 8 made mention of focusing on building good relationships with resources, which ultimately would make managing team resources easier but made no specific mention of collaborating with team members for activities related to managing projects.

From Table B5, Appendix B , question 7 sought to find out what participants considered to be key skills for project managers to have in the RE space in South Africa. Figure 11 shows a summary of the frequency certain key skills that were mentioned by participants. The breakdown of the skills mentioned by each participant is shown in Table 2. Financial management skills was mentioned the most by 5 participants (participant 1,2, 3, 6 and 8). Stakeholder management skills, technical skills (referring to technical skills in the energy space), and knowledge of the political and energy landscape came tied for second place with three participants mentioning each of these skill sets. Change management, people skills, time management skills, negotiating skills and leadership skills were mentioned twice by participants. Lastly, adaptability,

knowing how to use PM tools, language skills (in the context of communicating with communities where projects are deployed) and communication skills were mentioned only once.

Table 2: Key skills mentioned by participants for project managers in the RE space

Skills	Participant							
	1.	2.	3.	4.	5.	6.	7.	8.
Communication skills		Yes						
Language skills	Yes							
PM tool usage			Yes					
Adaptability				Yes				
Leadership skills		Yes						Yes
Negotiating skills	Yes	Yes						
Time management	Yes	Yes						
Risk management skills		Yes		Yes				
People skills		Yes				Yes		
Change management				Yes	Yes			
Technical skills	Yes					Yes		Yes
Knowledge of political and energy landscape	Yes				Yes		Yes	
Stakeholder management skills	Yes		Yes				Yes	
Financial management skills	Yes	Yes	Yes			Yes		Yes

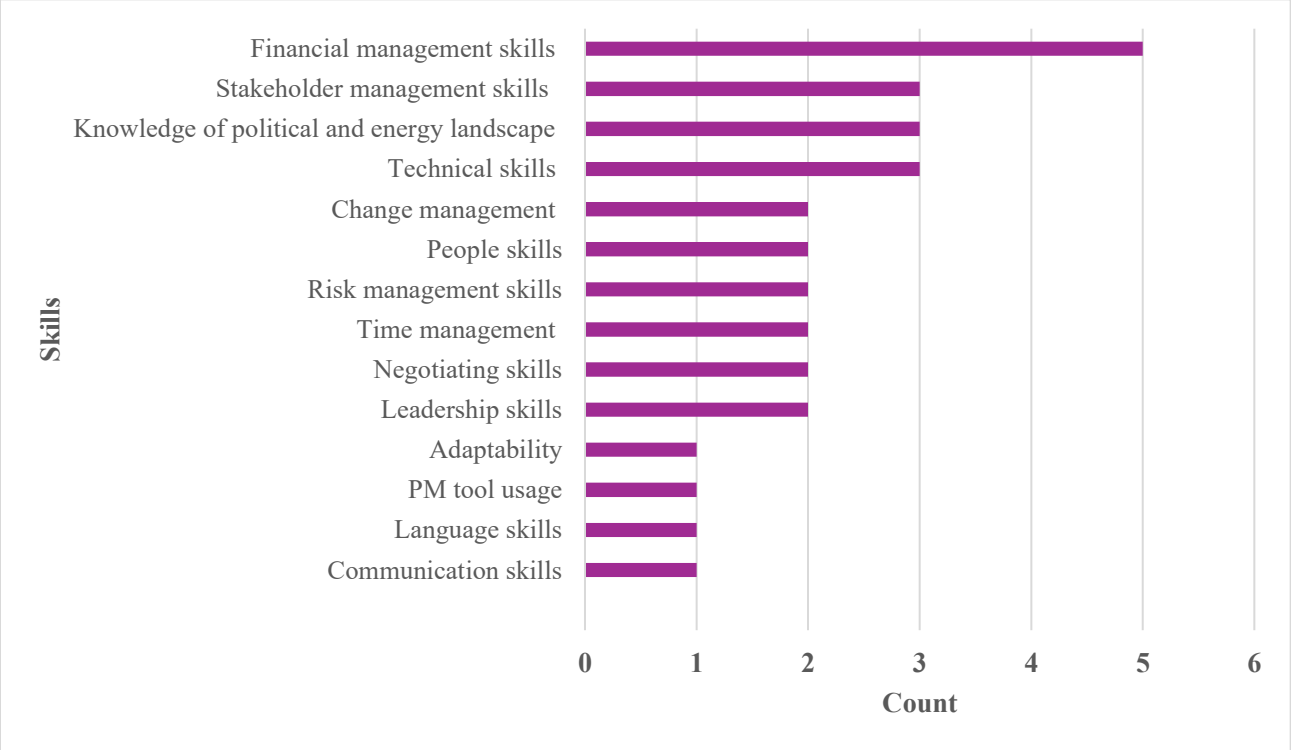

Figure 11: Summary of key project management skills mentioned and number of times each was mentioned

Figure 11 provides a summary of key skills mentioned (compiled from feedback of question 3 and question 7) and the number of times each was mentioned. Question 3 and question 7 have been grouped together to fall under the *a priori* theme project management style and skills. This is because the project management style a PM tends to use informs the skill set one needs to develop to successfully execute a project. From the findings in question 3 it is clear that the majority of the participants tend to lean towards a more collaborative approach with project team members and hence skills that this style requires, based on what was mentioned under key skills would be stakeholder management, leadership, communication, negotiation skills, adaptability. It is noted that given that the majority lean towards collaboration, the skills mentioned that facilitate collaborative styles (with the exception of stakeholder engagement) were mentioned twice or less which shows that overall participants consider 'hard skills' for project managers in the RE space to be a priority when considering what they require to make projects more successful even though the overarching project management style in the sample group is collaborative.

Theme 4: Project success and project efficiency criteria

From Table B 6, Appendix B, question 4 aimed to understand participants' definition of a successful project and attempted to collate these definitions into one that could be used as a common definition. Included in all the answers for question 4 was that a successful project is one where a project is completed on time, on scope and on budget where the project beneficiation must be clear. In addition, participant 2, 5 and 8 mentioned that a successful project is one that meets the client needs. Participant 3, 7 and 8 mentioned that a successful project also considers that the work is of high quality. Participant 4 included that a successful project is one where risks were managed accordingly and that positive feedback from project team members is an important factor that counts towards success.

From Table B6, Appendix B, question 5 aimed to understand participants' measure of project performance and attempted to collate these into common measures projects can consider using. Participant 1, 2, 3, 6, 7 consider adherence to cost, scope and budget together with client needs being met are the measures of project performance. Participant 4 considers positive feedback from project team members on the quality of work produced and project manager satisfaction a measure of project performance. A similar sentiment is shared by participant 5 that project performance measure is based on the performance of the project team. Participant 5 included that the project deliverable should be of a high quality. Participant 8 measures project performance based on if the requirements have been met.

From Table B6, question 6 in Appendix B is similar to question 5 except participants were asked how they define project efficiency with the aim of a common definition. Participant 1, 2 state the project efficiency is defined through the dimensions of adhering to scope, time and budget. Participant 1 added that it is defined by resource utilization as well. Participant 3 considered that project efficiency is defined through the relative effect a project has on the overall organization. Participant 4 and 5 defined project efficiency through how time is managed. Participant 6 mentioned that the definition is minimization of wasteful time and expenditure. Participant 7 and 8, like participant 1, defined project efficiency by resource utilization. Participant 7 went on to expand by adding that efficiency is when one can get the "best quality for the least amount of money with the most competent resources possible".

In summary from the findings, project success is defined by meeting the triple constraints (time, cost and scope) while also ensuring that clients are satisfied (this has been mentioned by roughly half of the participant group), deliverables are of high quality, there is effective risk management and positive feedback from the project team. Project performance measures mentioned are the same as how project success has been defined (with the exclusion of efficacy of risk management included in the measures based on participant feedback). Project efficiency is defined by optimization of resources, time and cost, including the considering the relative impact on the organization a project team is part of. Project success is more likely achieved when project performance is strong and when project efficiency minimizes waste in resources and time.

Ranking of requirements

Regarding question 8, the resulting ranking from each participant is shown in Figure B1 – Figure B8 in Appendix B. The overall ranking considering all the inputs of each participant is shown in Figure 12 below. This was calculated by adding up the ranking position of each requirement and dividing it by the number of participants thereby giving the average score of the group. Given that 1 represents the highest ranking and 12 represents the lowest ranking, the lowest average score that results from the group of requirements, refers to the requirement considered to be the top priority in South Africa to place effort. The overall requirements ranking showed that *clear project definition* is regarded as the most important requirement in South Africa, followed by *identifying the business case* and then *proper selection of team members*. *The project manager assigned to the project and their managerial skills* came in fourth place together with the *proper project planning and defining project parameters*. In fifth place is the *culture and leadership of the project manager*, followed by having *sufficient and suitable resources/tool availability for the project*. *Information flow* came in 7th place and *technical skills of the project manager* in 8th place. *Project governance* came in 9th place and *cooperation with implementation institutions* came in 10th place. *Quality*

assurance came in 11th place. *Closure of the project* was almost unanimously chosen as the least important requirement in the South African context as this has to do with documentation/hand over of the project only. The results show that the most important requirements regard the early stages of microgrid projects. The results also show that the selection and skills of the project manager rank highly because they are a significant driver toward project success.

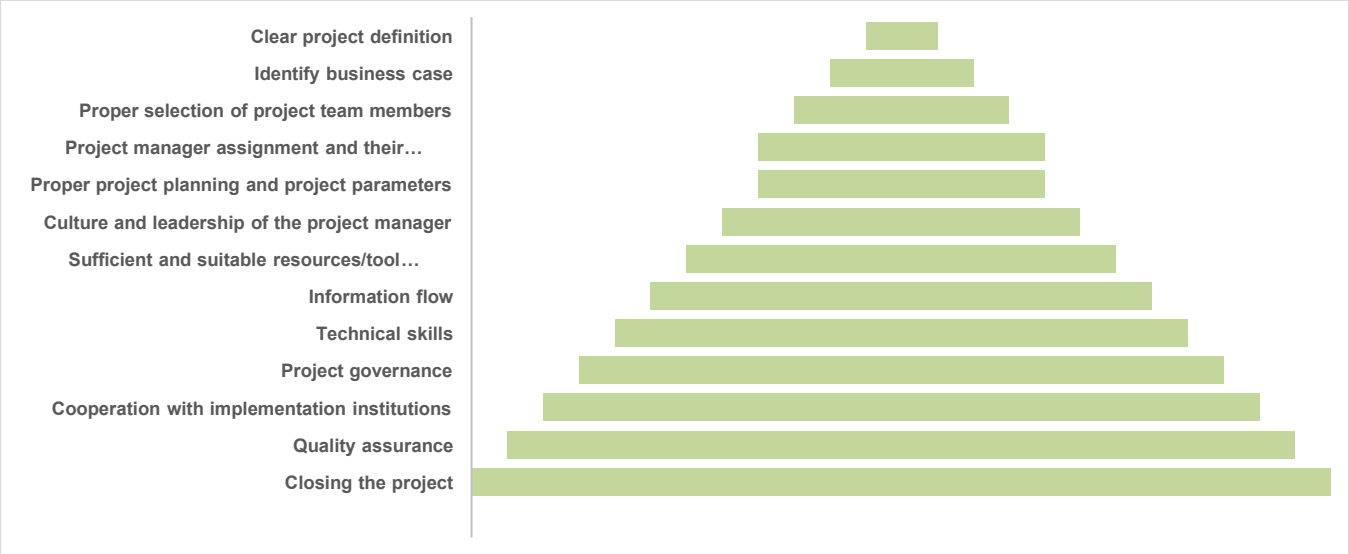

Figure 12: Overall requirements ranking by considering all participant input

Content validation

Content validation for the first set of interview questions are contained in Appendix A and participant 1 (pilot participant) provided the answers. Question 1 sought to find out the clarity of the questions being asked to which the response was that the questions were clear. Question 2 sought to find out other aspects that could be considered in the discussion for the first set of interview questions that were going be asked when interviewing participants 2 – 8. Feedback from by participant 1 included highlighting the role the political landscape in South Africa plays in the project management in rural microgrid projects. The issue of corruption and the impact of projects would be interesting to discuss with the participants, however it may be controversial and could result in hesitancy to provide transparent feedback from participants. A discussion on the ethics in the space would be an interesting angle as well. Question 3 sought to find out if the questions were appropriately challenging for senior level experts. Participant 1 answered that the questions were appropriately challenging. Therefore, from the feedback from participant 1 it can be concluded that the data validity was confirmed.

To confirm the rigor and reliability of the data, tools such as an audit trail can be used. Bowen (2009) states that an audit trail is a way to scrutinize the methodological and theoretical decisions made in the research process. It is aimed at increasing the trustworthiness of the naturalistic inquiry undertaken (Bowen, 2009) and document the course of developed and completed analysis (Carcary, 2009). Lincoln & Guba (1985) as cited by Carcary (2009) state that there are six categories of information that inform the research audit process. These include raw data collection, reduction of the data and analysis, reconstruction/synthesis of the data, process notes, materials related to intentions and dispositions and finally, preliminary development information.

In terms of the research carried out the research audit trail can be described as follows: the raw data is the audio recordings of both sets of interviews which capture verbatim feedback from participants together with the transcripts of the responses. The reduction of the data and analysis is down via records of the coding process from the interview questions is captured in Appendix B and thereafter, the *a priori* themes are linked to the developed codes. The questions and therefore codes, that are linked to the same identified *a priori* themes, were grouped together and analyzed as evidence speaking to those respective themes. The process notes include the documentation of the methodological decisions is outlined in section 3.1 (instrumentation, sampling, data collection and data analysis) and the justifications for the decisions taken. Materials related to intentions and dispositions include the ethics clearance obtained prior to any interactions with the participants (ethics clearance number MIAEC 021/24). The preliminary development information was informed by the literature review which heavily influenced the formation of the interview questions. Therefore, given the audit trail described the credibility of the research methodology has been demonstrated.

4.2.2. Part B - Gaps and challenges regarding project management in renewable energy microgrid deployment in South Africa

Question 1

Table B7 in Appendix B shows the codes developed from question 1 in Part B where the focus is identifying where and what challenges can occur in the project management lifecycle (initiating, planning, executing, monitoring and controlling, and closing/final phases) from participant experience in South Africa. Table 3 shows individual participant feedback for question 1, part B.

Table 3: Participant feedback for question 1 part B

Challenge	Participant							
	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**
Stakeholder management	Yes	Yes	Yes	Yes				

Performance and monitoring measures not clearly defined	Yes	Yes			Yes	Yes	Yes	
Communication		Yes	Yes					
Poor scope definition		Yes			Yes			
Poor identification and estimation of project costs		Yes						
Identifying solid business case of microgrid projects			Yes					Yes
Access to appropriated tools and technical resources			Yes					
Contract management skills				Yes				
Project conceptualization							Yes	
Data collection	Yes							Yes
Incorrect assumptions made during project	Yes							
Proactive risk management	Yes	Yes	Yes					
Resource management	Yes			Yes	Yes		Yes	
Linking project conceptualization to project activities							Yes	
Cost overruns	Yes	Yes						
Scope creep	Yes	Yes						
Time management					Yes			
Organizational culture					Yes			
Change management				Yes	Yes			

Interpersonal skills of project manager							Yes	
Proper project closure reporting	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Procurement management								Yes

Initiating Phase challenges

In the initiating stage, the feedback received highlighted that stakeholder engagements are a key challenge that emerges. Participant 1 mentioned answers related to this challenge such as communication with stakeholders, i.e., communicating the right message to the consumers of projects. Participant 2 mentioned communicating with other external stakeholders and participant 4 mentioned managing expectations effectively in the initial stages. Participant 2 mentioned poor scope definition, poor identification and estimation of project costs were identified as challenges as well. A challenge regarding identifying the business case of some microgrid projects and ensuring that they are financially sustainable was mentioned by participant 3 i.e. there is still a perception among several groups in South Africa that microgrid projects are a 'nice to have' and not a critical tool in South Africa to accelerate complete energy access. Related to the topic of the business case, it was mentioned that it can be challenging to convince investment committees of the viability of projects and their alignment with the organisational objectives , as mentioned by participant 8. This, to an extent, is in the control of the project manager, but they can have a significant impact on the outcome of getting a project approved if a clear business case is formed from the beginning. Conceptualizing projects was also identified as a challenge which alludes to unclear formulation and understanding of microgrid solutions. This could ultimately negatively impact project execution as mentioned by participant 7 . Thus, in the initiating stage of projects in South Africa, the challenges/themes that come from participant feedback are stakeholder management (which was the most frequently mentioned at initiating stage), scope management, and communication.

Planning Phase challenges

In the planning stage, given the nature of the novelty of RE microgrid projects where often there is limited prior implementations to draw learnings from, quantitative data collection is often a challenge as mentioned by participant 2 and 8 considering that some of the data may be sensitive. Participant 1 said that assumptions tend to have to be made with projects and given that the energy landscape is fast evolving, especially in the renewable energy space, these could be incorrect or inappropriate when execution needs to occur. Data collection challenges and the forming of assumptions in projects in the planning phase points to risk

management in projects. Other related responses from participant 1, 2 and 3 were that risk management is not done proactively i.e. risk are not identified or assessed upfront. Appropriate resource allocation and resource management was pointed out several times by different participants (participants1, 4, 5 and 7) as a challenge in the planning stage – this includes human resources, material resources and tools for project management (i.e., tools are not always available or are inappropriate for the proposed project). Linking project conceptualization to project activities was mentioned as a challenge by participant 7 which speaks to scope management challenges. Therefore, in the planning phase, the main challenges are risk, resource, and scope management challenges. Risk management challenges were the most mentioned.

Execution Phase challenges

In the project execution stage, cost overruns and scope creeps was mentioned by participant 1 and scope redefinitions was mentioned by participant 2. These are tied to budget and scope management. The lack of effective communication strategies during project execution was mentioned by participant 3. Having a good understanding of client expectations as well as working with external contractors on projects was mentioned by participant 4 which speaks to stakeholder management. It was mentioned that given that RE microgrid projects do not have a wealth of information to benchmark at the moment, especially in the South African context, sometimes project team members have been uncomfortable in the face of new knowledge and turning that into practice as mentioned by participant 5. This speaks to capacitating resources (resource management). Participant 5 mentioned that there is an ethos of lack of a spirit of pioneering in developing Africa and that there is a lack of invention/empowerment in African RE microgrid projects in this space as we are reliant mainly on what has been done in other parts of the world to guide our projects, and this may be inappropriate for the South African context. This topic alludes to an organizational culture challenge which impacts the culture in project teams and change management issues. Participant 4 also made mention of change management challenges. Working with diverse teams was mentioned as a challenge by participant 7 (this includes considering cultural backgrounds and different technical backgrounds as many RE microgrid projects are multidisciplinary). This has to do with interpersonal skills of the project manager mostly. An issue around procurement was mentioned by participant 8– sometimes the equipment required for deployment of RE microgrids may not be available in South Africa which means that it would need to procure internationally. The challenge here, apart from potential higher costs is that the procurement policies in several companies may prefer South African suppliers which is not always possible. This could impact cost and timeline of project completion. Therefore, in the execution stage the themes in the execution stage are scope management (the item mentioned the most), resource management, procurement management, project management skills, organizational culture and change management.

Monitoring and control Phase challenges

In the monitoring and control stage, a challenge was mentioned by participant 1 that if performance measures for monitoring are not clearly defined it makes monitoring difficult. Participant 1 and 4 stated that in terms of control, if risk management is not done in the planning stage, it also becomes a challenge. Participant 4 mentioned that a project manager would need to ensure that when feedback is required from stakeholders during monitoring, that the stakeholders understand the importance of the feedback and what is asked of them. Thus, themes in the monitoring and control stage are stakeholder management, communication, and risk management (risk management was mentioned the most).

Closure Phase Challenges

In the project closure stage, participant 1 mentioned exhaustion/fatigue that team members may experience as a challenge, and this can result in rushed documentation or missing documentation which can impact the successful closure of the project. Closure includes documenting lessons learnt and handing over information which is not always done as mentioned by participant 3. This is important given that the more documentation one has for RE microgrid projects, the more repeatable the process could be. Participant 6 expressed another challenge communicating the benefits of the projects to recipients once it is completed – it hasn't always been clearly understood by community members who the project is meant for which can make them resistant to accepting a change into their community. Participant 2 mentioned that resources may be constrained towards the end of project if there were prior challenges which can make project closure take longer than expected. Therefore, the themes in the project closure stage are resource management (the most mentioned) and communication.

Question 2

Table B8 in Appendix B shows the code development for question 2, question 4 and question 5 in Part B of the interview 1. Question 2 refers to the compiled requirements that were done in Part A of the first set of interviews and asks what the participants think is not sufficiently addressed in terms of these requirements in South Africa. Challenges that were mentioned by participant 2 include that there is a lack of a development pipeline of skills for the deployment of the microgrids and that any missing skills there is a tendency to more often than not, outsource rather than to build capacity within the country. Identifying the business case, clear project definition, stakeholder management (communication with them), were mentioned as challenges by participant 2. Proper selection of team members is sometimes not done well in South Africa, (understanding the roles of team members) and skills are not suited to the project sometimes was mentioned as challenges by participant 3. Cooperation with implementation institutions was pointed out as a challenge by participant 4 – these institutions have the power to bring projects to a halt if not dealt with effectively. Leadership issues were mentioned by participant 5. Participant 6 mentioned that project

managers require technical skills related to RE projects and RE microgrid projects to be able to effectively execute projects – this is not always the case as some project managers are assigned but lack sufficient technical skills to effectively manage projects which can affect project efficiency. Participant 7 mentioned clear project definition is a challenge as well as information flow within projects as well. Participant 8 mentioned that technical skills are not being sufficiently addressed in South Africa in agreement with participant 6. From the feedback of this question, it appears that capacity building and clear project definition recurred twice each while the others are mentioned once.

Question 4

Closely linked to question 2 is question 4, in Part B, which speaks to what participants think are key project management skills that are missing in South Africa. The responses included in question 4 were, resource and risk management, project governance, leadership, cooperation with implementation institutions, negotiation skills, stakeholder management, financial and technical skills from participant 1. Participant 2 mentioned interpersonal, communication and leadership skills. Participant 5 also mentioned leadership. Participant 6 mentioned social expertise skills are missing. Participant 7 mentioned conceptualization and planning skills are missing and lastly, participant 8 mentioned financial management and technical skills are lacking. Leadership was mentioned the most among participants.

Question 5

Question 5 in Part B sought to find out additional challenges not considered/mentioned earlier in the interview that may arise as more RE electrifies rural villages. Participant 1 stated that community engagement in terms of having language skills to connect with the local communities. Participant 3 stated a good structure for community ownership must be established for RE microgrids. Participant 4 mentioned that as time goes there may be a shortage of project management professionals in the space if there are no proactive interventions to capacitate professionals.

Question 3

Table B9 in Appendix B shows the code development for question 3- part B. It sought to gain insight into the prevalence of the involvement of experts in the space in RE projects and/or RE microgrid projects after they are commissioned. About half the participants have not been involved post commissioning but a few have mostly in monitoring and evaluation of the projects but not for the whole duration of the lifetime of the projects. This points to having a plan for the longevity of the project even if it is not the same project manager going forward for the project lifetime. It provides insight into what works for the communities and

what can be improved throughout the lifetime, but this is not always possible as project funding is often limited to commissioning hence the importance of community ownership structures.

Figure B9 – Figure B16 in Appendix B, show the ranking of challenges from most pressing to least pressing from each the participants. Figure 13 shows the overall ranking of the challenges from the collective input from the participants. This was calculated by adding up the ranking position of each challenge and dividing it by the number of participants thereby giving the average score of the group for each challenge. Given that a ranking of 1 represents the highest ranking and 7 represents the lowest ranking, the challenge with lowest average score refers to the challenge considered to be the most pressing in South Africa by the sample group. The top ranked challenge in South Africa is leadership and communication deficits. Adapting solutions to local contexts follows (this means that RE microgrid solutions are not a 'one size fits all' and must be tailored for specific communities. The third highest ranked challenge is project scope challenges – from the previous questions in part B, scope management being a challenge has been mentioned several times. Fourth on the list is key decision making by main management which is the strategic management of organizations under which projects fall. This can have a major impact on the success of projects and especially the process must be repeatable. The technical expertise of the project team came in fifth. Most participants were of the opinion that we do have the skills in South Africa, it is more a matter of appropriately allocating them and managing them that's more of an issue. Lack of expertise in managing RE projects came in 6th which means most of the experts are of the opinion that South Africa has sufficient expertise to execute projects well. Last on the list of challenges has to do with mismanagement by and lack of commitment from project managers which appears not as major an issue as all the others mentioned.

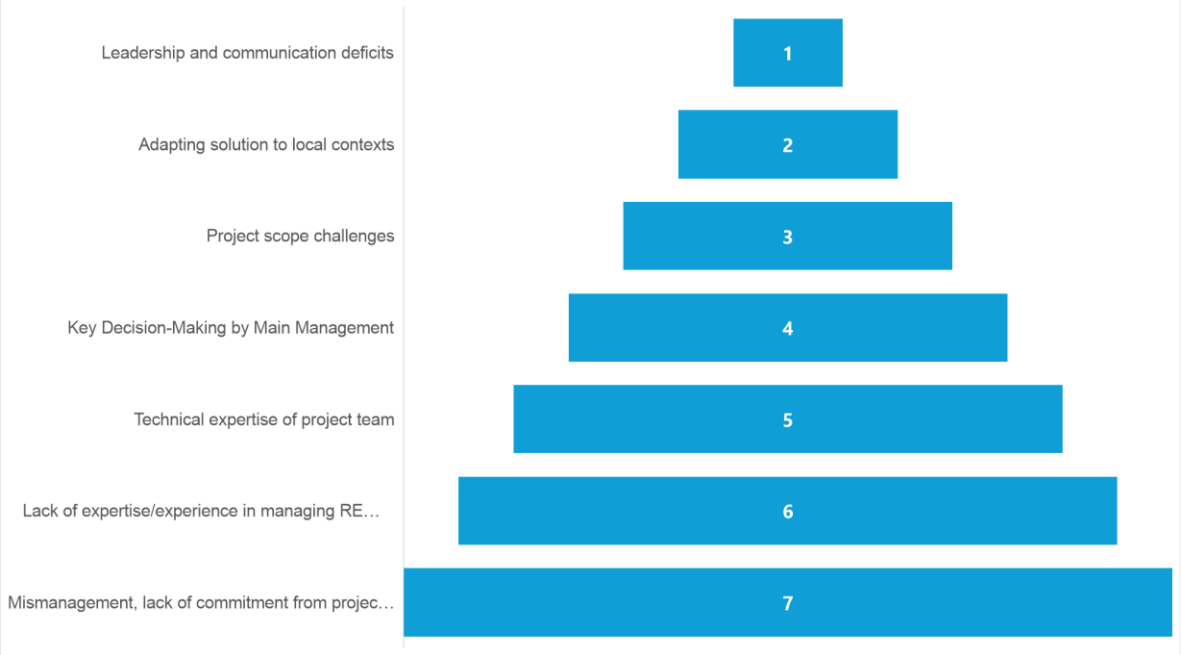

Figure 13: Overall ranking of challenges from participants

4.2.3. Thematic analysis

In this section a combination of the *a priori* themes developed from the literature and emergent themes which contribute to successful project management from both part A and part B of interview 1 are shown in Figure 14. The main themes are project management tools and techniques, project success criteria, project management style and skills, culture and leadership. The only emergent theme from the interview process was project management style, which was merged together with project management skills, given that as discussed, the project management style used informs the required skills. The recommendations for successful project management are then developed according to these themes.

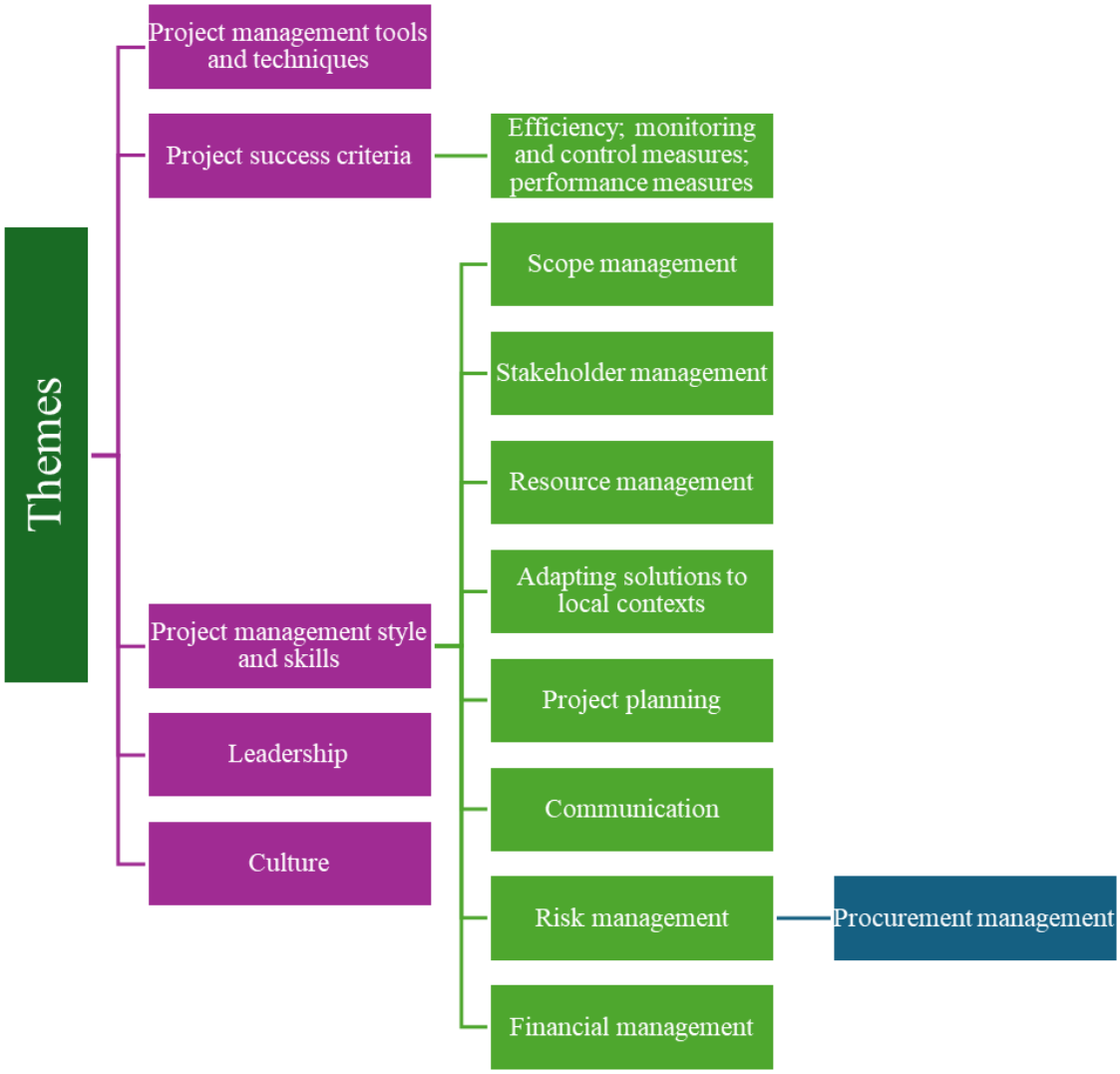

Figure 14: Combined themes from literature review and interview feedback

4.2.3.1. Impact of the themes (Figure 14) on project efficiency (second set of interviews)

The question in the second set of interviews aimed to assist in determining where efforts should be prioritized under that selected themes to improve project efficiency. From participant feedback (detailed feedback is contained in Appendix C), leadership appeared to come up as the theme that would impact the project efficiency the most (4 participants), followed by project management style and skills (3 participants) and finally culture (1 participant). The reasons behind leadership being chosen were that if it is indecisive, projects will not have sound direction and can be derailed. Under project management style and skills, one participant expressed that scope management, risk management and communication are the top three subthemes that will most significantly impact project efficiency. The rationale here was that proper scope management is strongly interlinked with the other subthemes in project management style and skills,

ensures that time management issues are minimized, and proactive risk management avoids pitfalls in projects. The other participant that selected project management style and skills highlighted that the subthemes stakeholder management and change management have the most significant impact on project efficiency. In the South African context, most of the projects are undertaken with stakeholders, who themselves do not always have clear expectations so stakeholder management becomes important. Stakeholder expectations may change along the way during a project, and this would touch on change management as well. The participant that selected culture as the theme that impacts project efficiency the most reasoned that it is because culture is made up of having accountability and key performance indicators. Role modelling is important in organizations as it offers guidance on how the organization would like employees to conduct themselves. This can indirectly impact project efficiency and have a considerable impact on project success. Overall, the feedback from participants has shown that leadership is the item that needs to be improved upon in the South African context.

CHAPTER 5

DISCUSSION

The findings of the study highlight several *a priori* themes from the literature review which informed the questions developed for and two sets of interviews. The critical research question aimed to investigate how a framework for renewable energy microgrid projects can be developed to improve the efficiency of the deployment of these projects in South Africa. The methodology used to address this research question was through the research objectives. The research objectives guided the methodology used to address the critical research question.

5.1. Project management frameworks for RE microgrid projects

The first research objective was to investigate successfully used project management practices in RE microgrid projects and larger scale renewable energy projects (with focus on the applying renewable energy project management practices of larger scale projects to RE microgrid projects). From the critical literature review conducted, a review of project management frameworks used for RE projects were highlighted. These were PMBOK, CPM, CCPM, PERT, Waterfall, PRINCE2, Agile and Lean methods. CCPM and PERT are more suitable for dynamic and uncertain projects while PMBOK and PRINCE2 provide structured approaches for standard or large-scale projects. Typically, the Waterfall method tends to be the most commonly used method for RE microgrid projects in South Africa and it has advantages of being relatively simple and straightforward. The drawbacks however are that changes in the project may be challenging and costly to implement and problems are difficult to anticipate making it inefficient. There are benefits to the other methods that overcome the shortcomings of Waterfall method mentioned.

In the literature review, Roy & Palikhe (2023) discuss how traditional project management techniques may not fully address the dynamic nature of renewable energy projects and suggest methods that are not typically used in the energy space. These are Agile and Lean, and this could improve traditionally used methods, i.e., Waterfall, in terms of team collaboration. Adegboyega, et al. (2024) also cited an example where Agile was used to foster collaboration with local communities for a community coupled microgrid. A challenge was identified, both by Roy & Palikhe (2023) and participant feedback with these alternative methods, that there may be reluctance of project managers in the RE space to widely adopt them even though they allow for improved control of projects. These alternative methods are more complex to understand and apply. These findings are consistent with participant feedback about Waterfall method being the most preferred due to its simplicity. The PM tool most used often by the participants overall is Microsoft Excel largely owing to

its simplicity for smaller scale projects. Given that only one participant has a formal qualification in project management, this may have skewed the data that was used in the data collection phase of the research. This is particularly evident regarding the preferred project management frameworks that have been used for projects by participants. It is more likely that a formal qualification in project management would expose a participant to more frameworks other than Microsoft Excel. This could influence the outcomes among participants regarding more commonly used project management methods/frameworks for RE microgrid projects.

5.2. Successful RE microgrid project management practices

In terms of the successfully used project management practices outlined for larger RE and RE microgrid projects in the literature, these include community ownership models (e.g., a successful community owned model for RE microgrid as discussed by Tozzi & Katre (2018)). Hermawati & Rosaira (2017) demonstrated the criticality of community participation which contributes to project success and sustainability. This shows the importance of community engagement and building trust. Important to note by Eklund et al. (2023) is that the level of social cohesion and dynamics plays a role in the level of engagement that can be achieved and that fragmented communities could have challenges with this. In the South African context, communities that are divided due to political views could make building trust a challenge. This highlights the importance of considering the socio-political landscape in South Africa when community engagement facilitation and mediation measures are developed. Training and educating local operators, technology and its related efficiency education as demonstrated by Soshinskaya et al. (2014) is instrumental and linked to community participation. Guidance on best practices in managing public RE projects was mentioned by Mokan et al. (2019) in terms of sharing responsibility between project stakeholders and stakeholder cooperation. Shared responsibility goes beyond just community participation but speaks to community ownership as well. A sense of ownership is likely to reduce resistance/sabotage to potential projects.

Proactive risk management was identified as key to success and Kozhakhmetova & Anarkhan (2024) demonstrated the benefits of risk management through the PMBOK-based risk management processes which significantly improves project success rates. Kozhakhmetova, et al. (2019), from their research where several RE energy projects were analysed, showed that although that these projects had proper scoping, scheduling and cost estimation in common, they lacked risk, quality and communication planning which is indicative of where the areas of improvement for RE projects are. This shows a possible imbalance in RE project management priorities between focusing more on scope/scheduling (elements of the iron triangle) and less on continuous risk management, communication and quality. It also shows that maybe other aspects must be considered when evaluating a the definition of a successful project beyond the

elements of the iron triangle. This way, more learnings can be obtained and thus make the process more easily repeatable.

Project success to this point in the research largely focuses on the successful planning, execution and commissioning of RE microgrids. It was mentioned that post commissioning of a microgrid, that there is typically limited involvement of the project manager and project team to ensure the microgrid reaches its useful life. One aspect that must be considered is the quality of energy access provided by commissioned projects. In 2015, the 2030 Agenda for Sustainable Development was adopted by United Nations Member States (of which South Africa is a member) (United nations, 2025). The Agenda for Sustainable Development provides a roadmap/blueprint for global peace and prosperity for the present and the future.

The agenda has 17 Sustainable Development Goals (SDGs) which are a call for all the countries in the global partnership to achieve (United nations, 2025). SDG number 7 is the goal that focuses on affordable and clean energy access for all. The successful deployment of RE microgrids contributes to achieving clean energy access. The definition of energy access, however, is not universal and there is difficulty measuring energy access against existing definitions in a precise way. So, where an RE microgrid has been deployed, whether or not it provides energy access as it is intended to speaks to the quality of supply. Project success as defined by literature and participant feedback take a somewhat limited approach. The decider is if certain dimensions are fulfilled for success or not (e.g., either a customer is satisfied or not). However, Bhatia & Angelou (2015) state that this tends to paint a narrow picture and neglects to consider the multiple dimensions of energy access. Bhatia & Angelou (2015) state that energy access is a multidimensional issue and that it must be measured across several indicators that capture different elements. There can be multiple indicators which makes drawing meaningful conclusions about what constitutes energy access challenging. Therefore, models that aggregate these indicators would be very useful. An example of such a model that considers multi-tier indices is called the Multi-Tier Framework (MTF) for measuring the level energy access. The MTF was developed by World Bank in July 2015. The MTF provides information on the quality of the service received by users, with focus on the specific attributes of availability, adequacy, reliability, affordability, safety and impact on user's health and legality. There are five tiers (where tier 0 – no access to tier 5 – highest level of access) for each attribute which describes the level of energy access by an energy solution. This highlights that although an RE microgrid project may successfully be deployed as per the established definition from the findings in the research and participant feedback, frameworks such as MTF reveal the shortcomings in the definition of project success and that other aspects could be considered to expand the definition of project success particularly for rural RE microgrid projects with varying energy needs (Sustainable Energy Africa, 2016).

5.3. Challenges in RE microgrid project management

Part of the second research objective was to determine challenges experienced in RE project management practices. The findings from the first set of interviews shows that in terms of the project life cycle the main challenge in the initiating phase is stakeholder management, in the planning phase is risk management, in the execution phase is scope management (consistent with the views of Igielski (2023)), in the monitoring & control phase is risk management and in the closure phase it is resource management. This reveals that risk management is the top concern throughout the project lifecycle based on participant feedback. This means more effort must be directed here. Song, et al. (2025) support the stance that risk management plays a crucial role in ensuring favourable project outcomes. Song, et al. (2025) examine the impact of risk management on sustainable project performance in the construction industry and include analysing the role stakeholder management plays in this regard. Risk management practices mitigate uncertainty particularly for emerging economies (such as South Africa) where there are infrastructure gaps and limitations on resources (Song, et al., 2025). The construction industry – a key player in RE microgrid deployment in South Africa – faces challenges such as political instability, limited resources and regulatory changes similar to other emerging economies such as Brazil and India. This places inherent external risks to the success of projects. These construction industry challenges strongly influence risk management and stakeholder engagement. The construction sector in South Africa is dominated by public sector involvement (Song, et al., 2025). Socio-political factors such as efforts for land reform and labour strikes also play a significant role in the construction industry in South Africa. This could likely be one of the reasons that adds to the uncertainty when managing RE microgrid projects in South Africa.

A key insight from Song, et al. (2025) is that in these emerging economies, structured risk management is an enabler of improved resource allocation, minimizes project disruptions, and it improves the likelihood of successful project delivery. Furthermore, stakeholder management is identified as an amplifier of risk management strategies so therefore proper stakeholder management positively impacts risk management (Song, et al., 2025). If risk management is not addressed, RE microgrid projects risk delays, cost overruns, and community pushback which are already characteristic of infrastructure projects in South Africa. The findings from the participants and Song, et al. (2025) both show that in the project cycle, proper risk management is likely to be the most impactful in ensuring a smooth project lifecycle.

According to participants, in terms of the opinions on what key requirements were not sufficiently addressed, the requirements mentioned were clear project definition and capacity building. The capacity building referred to was in terms of the project managers sometimes having a shortfall in technical skills for RE microgrid projects as well as the selection of project team resources. Capacity building was also

described in terms of developing a pipeline of skills in the RE industry for microgrid deployment. Clear project definition being a requirement that is not sufficiently being addressed can closely be linked to stakeholder management being identified as the main challenge in the initiating phase of projects. Inadequate definition can result in differing stakeholder expectations and therefore may impact stakeholder buy-in.

In terms of capacity building, Mathee (2022) agrees with the views of the interviewed participants and states that the skills gap in renewable energy project in South Africa extends to a lack of real-world experience as well. Certified, but inexperienced individuals require more on-the-job experience to improve skills transfer (Mathee, 2022). Furthermore, broader skills development and transfer must be considered (such as finance and entrepreneurship skills) to ensure that communities can increase their economic impact (Mathee, 2022). This would positively impact the long terms sustainability of deployed projects.

The challenges (in order of the ranking by participants from most pressing to least pressing challenge) in South Africa started with *leadership and communication deficits* followed by *adapting solution to local context*s, *project scope challenges*, *key decision making by main management*, then *technical expertise* of the project team then *lack of expertise in managing RE projects* and lastly *mismanagement by and lack of commitment from project managers*. These results show that leadership and communication deficits (communication challenges was also identified as a challenge by Daramola et al. (2024) and Zakaria & Ahmadian (2019)) is the most significant challenge in the South African context. Espin (2022) states that in South Africa the stakeholder landscape can be complex in the renewable energy space. This could likely be a contributing factor to why project leadership can be a challenge. A relevant example is the Renewable Energy Independent Power Producers Programme (REIPPP). The REIPPP is a public-private sector competitive procurement program with the goal of rolling out renewable energy in South Africa to mitigate climate change (NDC Partnership, 2016). The REIPPP does not mandate that stakeholder engagement from early stages of project and Espin (2022) states baseline community studies would assist in early and proactive risk identification. Companies will generally limit interactions with potential project stakeholders when they are still in the bidding for RE projects since they have not been awarded the project yet. However, in EIA processes, for example the requirements for economic development compliance such as job creation are difficult to adequately describe because a community baseline would strongly inform such compliance. Although the REIPPP focuses on RE generation connected at utility scale, the similar challenges are likely experienced with RE microgrids. There are several types of stakeholders including (but not limited to) traditional leaders, community forums and local government (Espin, 2022) and this requires strong leadership to be able to coordinate well for projects (Espin, 2022). The complex stakeholder landscape could also be a contributor to communication challenges since these different groups must be

communicated to differently. If leadership and communication deficits are not addressed, there are likely risks of project delays, cost overruns or ultimately rejection of project by communities.

The fact that adapting solutions to local contexts is regarded as the second most pressing challenge points to a greater need for understanding the needs of the communities in which these RE microgrids would be deployed. Funder, et al. (2021) states that likely reasons why adapting solutions to local contexts remains a challenge in South Africa is that local communities or those representing the interests of local communities may feel that they are being excluded from the benefits and planning processes in RE projects and a perception of negative impacts on cultural values and livelihoods. This would be even more pronounced in communities that have little to no knowledge of renewable energies. Beyond just a project manager ensuring that there are skills within the project team to consider local contexts, Funder, et al. (2021) argue that community engagement professionals should be considered as a standalone function in RE projects in companies as opposed to extensions of leadership within energy companies. This could contribute to the body of knowledge in this subject given the diversity of communities in South Africa.
Community engagement was identified in the successful practices several times and a lack of engagement is strongly linked with projects being unsuccessful. Nombakuse (2019) demonstrated a case of this, in South Africa where the lack of community engagement was detrimental to the success of a microgrid in the Eastern Cape.

5.4. Requirements for successful RE microgrid project deployment

The second part of the second research objective was to determine the requirements for successful RE project deployment. The results show that the most important requirements regard the early stages of RE microgrid projects. The results also show that the selection and skills of the project manager rank quite high on the list because they are a significant driver toward project success. On the opposite end, the requirements that are lower ranked by participants (project governance and cooperation with implementation institutions) could potentially be attributed to the influence of the uncertainty in policy and regulation for renewable energies in South Africa. Hanto, et al. (2022) mention the inconsistent implementation of existing legislation and state interventions through various RE projects in South Africa. This highlights a lack of standardization. The fact that the participants ranked project governance and cooperation with implementation institutions on the lower end of the list could point to participants perceiving governance/institutional structures as secondary since they prioritize immediate project factors more. It could also be indicative of a low level of trust in these institutions. Hanto, et al. (2022) argue that to increase the uptake of REs there must be improved coordination of political efforts to allow the implementation at varying scales (small scale RE to large scale RE) of generation by uncomplicating

bureaucratic processes. This consideration must be accounted for at industry level to accelerate RE microgrid deployment.

In terms of project management style, it is noted that given that majority of the participants lean towards collaboration, the skills mentioned that facilitate collaborative styles were mentioned at most twice. This shows that overall participants consider 'hard skills' for project managers in the RE space to be top of mind when considering what they require to make projects more successful. This presents a contradiction because one would expect soft skills to be mentioned the most as key skills required. This view by participants contrasts with Ndlovu & Weeks (2013) and Zakaria & Ahmadian (2019) who consider soft skills to be more crucial in project success.

CHAPTER 6

DEVELOPMENT OF RECOMMENDATIONS OF PROJECT MANAGEMENT PRACTICES FOR THE SUCCESSFUL DEPLOYMENT OF MICROGRIDS BASED ON LITERATURE REVIEW AND SEMI-STRUCTURED INTERVIEW INPUTS

Successful practices, requirements and challenges mentioned for the successful design and deployment of rural RE microgrids have been described from the literature review conducted. This section considers these successes, requirements and challenges and describes a set of recommendations in the form of guidelines from the literature for the successful design and deployment of rural RE microgrids. The recommendations also consider the inputs from the first set of semi-structured interviews on the successes, requirements and gaps in the South African context including inputs from the second set of interviews on the applicability of recommendations from experts with project management experience.

6.1. Project management tools and techniques

From participant feedback from the second set of interviews, in terms of the recommendations for project management tools and techniques that may improve project efficiency and the likelihood of project success, most participants agreed that there is value in using techniques like Agile and Lean for microgrid projects as discussed in the literature review. Furthermore, if these methods are introduced in such manner that they complement the shortfalls of traditional project management methods it may be beneficial for microgrid projects that are rolled out at a larger scale. Another point to mention is that some project stakeholders or organizations may be averse to incorporating project management methods they are not familiar with or have a culture of resistance to replace existing tools. It was pointed out that measures such as the JIT processes for capacity building for team may be beneficial in theory to minimize project costs in the South African context, but a consideration must be made that if time management is not done well, then JIT may introduce risk in projects given that the learning rate of project team members being capacitated may be incompatible for the timelines set out. JIT was also seen as more of a reactive approach to capacity building rather than a proactive approach. Proactive capacity building appears to be more suitable for microgrid projects.

6.2. Project success criteria

From participant feedback, the success criteria for a project are:

- Projects objectives being met - this refers to a project being completed on time, on budget and on scope at the right quality for the customer. In addition to this, the project team members must also agree on the metrics for successful completion.

- The project beneficiation must be clear – it must be clear who and how the project benefits different groups.
- The project efficiency measures mentioned is adhering to the time for project delivery and if resource usage is efficient i.e., waste is minimized as per the company requirements (since companies may have different metrics).
- The safety requirements set out for the project are adhered to.

Participant feedback is in alignment with the definition/s mentioned by (Jarosz, et al., 2022) in the literature in terms of how to define project success. Therefore, considering both the literature and participant feedback, a successful RE microgrid project for rural communities is one where the defined scope, cost and time are adhered to, the customer is satisfied, the project beneficiation is clear, resource and time usage is efficient, and safety requirements are adhered to. However, as the discussion showed, this definition of project success may be somewhat narrow as it prioritizes deliverables and deadlines but neglects to consider other metrics like resilience, adaptability and the impact on the health of users.

6.3. Project management style and skills

6.3.1. Scope management

The participants agreed with the recommendations made to improve scope management as discussed by Emmanuel, et al. (2015) which is that there must be mechanisms established for scope review and verification and that robust communication plans with stakeholders must be developed. Emmanuel, et al. (2015) also mention that it may be beneficial to partner with experts in the RE space and draw on learnings from similar projects with comparable WBSs. There was a comment related to the stakeholder needs assessment in that it should be outcomes-based when the needs are being developed. One of the inputs was that partnerships and drawing from learnings from other projects may be challenging in South Africa because typically microgrid projects are done in a silo-oriented way which makes knowledge sharing difficult especially in terms of sharing project pitfalls. Therefore, there are limitations to how much information can be obtained from experts in the space which can impact the efficacy of this recommendation.

6.3.2. Stakeholder management

All the participants from the second set of interviews agree with the recommendations regarding improving stakeholder management as mentioned by Ezeh, et al. (2024) which were making use of stakeholder mapping, continuous engagement, establishing an effective communication plan, collaborative approaches, use of CRIs and conflict resolution measures. Additional comments from participants include that expectations must be communicated and managed often with stakeholders. There may be changes in stakeholders and proper handovers must be done if stakeholders leave during a project. Leadership in the

local community the microgrid will serve, may also change so this must also be accounted for in stakeholder management. In terms of CRI, it was recommended that sustainability be at the forefront, and this can be done via ensuring that sustainable jobs are created where possible. A consistent rating/feedback method with stakeholders would be beneficial to manage them. It was mentioned that the project beneficiation must be made clear to all stakeholder groups. One other aspect is to check the impact of the work done on stakeholders such as on-the-ground type of audits. Comparing commitments made versus whether they are being realized is important to make continuous improvements.

6.3.3. Resource management

The human resource practices in an organization can be a strategic tool to improve the skills in the renewable energy sector through tools such as capacity building for project team members (Eleogu, et al., 2023). This is important to microgrid projects. Skills mapping at the start of projects is recommended to gain an overview of the required skills for projects to ensure that all the required skills are available to successfully complete the project. From the feedback in the first set of interviews, the use of local resources in projects was emphasized, which aims to enhance community ownership. It was also mentioned that that a resource plan with resource levelling is recommended as this is beneficial in ensuring the project resources are not over or underutilized. From the feedback from participants the type of resources often referred to in the challenges are human resources. Therefore, this section speaks to human resource management. There was also a recommendation from the second set of interviews that there should be adequate budget associated with contingency costs for resource constraints.

6.3.4. Communication

Daramola, et al. (2024) mention the benefits of digital tools to improve communication in the literature review. It must be noted that digital communication may, for most rural microgrid projects, be limited to the project team and stakeholders that have access/are comfortable with technology usage. As identified by the participants in the first set of interviews and stated by Daramola, et al. (2024) barriers to communication are factors such as languages and diversity in cultures. This is especially important to overcome, as many rural communities in South Africa can have several different predominant language mediums. From participant feedback, it is recommended to solicit regular feedback from stakeholders and develop lessons learned documentation for future reference. Jarosz, et al. (2022) support the need for proper knowledge management in terms of learnings for improvements in subsequent projects and also assert that one of the main reasons for the success of projects in the energy sector is being able to use the experience of project managers in the space. Other recommendations from participants were:

- Establish communication methods for the internal project team members.

- Knowledge sharing workshops to sensitise the local community to the potential project and knowledge sharing workshops with professional peers as well. Interacting with professional peers promotes a better exchange of knowledge/experience in the RE space.
- Ensure that as much as possible there be at least one social expert and individual/s with the local language skills to communicate with the community. Local champion/s must also be involved to assist in conveying messages to the local community.
- Capacity building for project team members on effective communication techniques especially considering cultural sensitivities
- Platforms where concerns of stakeholders can be voiced.

6.3.5. Risk management

Adegboyega, et al.(2024) mention risk response plans for proactive risk management in the literature review. Probability impact matrixes is also another useful took for risk management (Project Managment Institute, 2000). Recommendations from the second set of interviews include:

- Risk reviews
- Site risk assessment. Project risk and risks that come up during implementation that may have not initially been identified must be accounted for through regular risk reviews.

6.3.6. Procurement management

Adegboyega, et al.(2024) mention developing good relationships with local and international suppliers as projects are done, to ensure sourcing is diversified as well as implementing robust inventory management systems to mitigate supply chain risks. In the context of the feedback received from participants, procurement management in this case was discussed in terms of managing the risk that comes with procurement delays and challenges associated with the need to, in some cases, export equipment and technologies from other countries. The need to import equipment places additional challenges such as the fact that the companies chosen must comply with certain requirements in South Africa. This can narrow the selection of suitable vendors. Recommendations to work around this could be:

- Participant 7 mentioned that if government organizations are involved especially with financing, then the Public Finance Management Act (PFMA) and Municipal Finance Management Act (MFMA) must be considered and understood well in South Africa. Inclusive procurement techniques tend to facilitate more inclusive procurement management.
- Participant 3 mentioned that the ease of procurement can depend on what capacity the procurer is in South Africa (e.g. Independent Power Producers). If bidders bid to supply equipment, it is important for the procurer to know who the suppliers are in terms of the Original Equipment Manufacturers that they're working with (both local and international) to ensure that they do not run short on supply.

- Participant 8 mentioned that it must be ensured that there is security for the equipment procured because this can be vulnerable to being stolen.

6.3.7. Change management

Feedback from the second set of interviews echo the sentiments from Rajpurohit & Jain (2023) and Odulaja, et al. (2023). It was mentioned that change management is crucial and should be emphasized more if microgrids are going to be rolled out more rapidly. Given that energy is transitioning into a new era as far as RE is concerned, there tends to be a lot of resistance among professionals. Therefore, change management interventions must be taken more seriously in organizations especially with microgrids which are decentralized. The energy industry is more accustomed to centralized power generation systems. Change management measures must come early on in projects (e.g., failures may happen and happen quite early so that project team members are more comfortable navigating this.)

Therefore, recommendations for improving change management include:

- Training and development for project teams and PM and eliciting leadership support as RE microgrids are relatively novel in South Africa.

6.3.8. Time management

From participant feedback, time management techniques/tools currently used for RE projects did not appear to be a challenge and majority recommended the use of various time tracking software where Gantt charts can be generated. With the Gantt charts the major processes defined under time management can be done (Richard, 2024).

Recommendations in this space from participant feedback include:

- Using time tracking software that can produce Gantt charts (mentioned by more than one participant) while ensuring the critical path in projects is clear (participant 3).
- When one creates project timelines, ensure that procurement lead times are well incorporated in the schedule including the allowance for time delays and the associated risk (mentioned by participant 3).
- Ensure you have sufficient reminders for the project team and your risk in terms of time is made clear for activities (mentioned by participant 8).

6.3.9. Financial management

Financial management in this context refers to the financial management skills and measures that a project manager can take to ensure that finances can be managed effectively. This includes capacity building for local communities so they understand what they will be paying for so that the financial goals of the project can be met (Sakanga, et al., 2020). Digital tools for financial tracking can be used to plan interventions where necessary. Zhelev & Kostova (2024) highlight the critical role in transforming financial control that digital tools play. Standard templates for financial planning can be used to provide an idea of the finances

for project to make the process repeatable (Morrison, 2022). Participant 7 recommended that a project manager must understand the financial model and economic plan for the project as well.

6.3.10. Leadership

This theme refers to the leadership primarily exhibited by a project manager. Some recommendations in this space that could improve the likelihood of success of a project include:

- Ensuring that organizational leadership provides support in these projects. Leadership is vital to sustainability, and the importance of sustainability must be communicated with these projects otherwise they will not be repeatable (Opoku, et al., 2015).
- The project manager can engage in leadership programmes/course to upskill themselves (Tarasova, et al., 2019) .
- From participant feedback, a recommendation was soliciting feedback from project team members throughout and after the project concludes for continuous improvement.

6.3.11. Culture

The culture of organizations is reflected in the values, norms, expectations and beliefs that they share (Project Managment Institute, 2000). This has a direct impact on the success of projects. Apart from the large influence organizational culture has on projects, the project manager as well has a significant role to play in the culture of a project being implemented. Some recommendations to improve the culture for a microgrid project:

- Project managers can strive to create a favourable culture for project team members. This can be done through measures such as team building activities, which is typically applied for group development interventions (Klein, et al., 2009).
- From participant feedback the following was recommended:
    - Role modelling needs to be emphasized (participant 7).
    - Continuous celebration of successes in the project helps in creating a favourable culture (participant 3).
    - Make sure to incorporate initiatives to create a positive culture with the local community and not just the technical team (participant 1).
    - Apart from the bigger organization that employees belong to, every project on its own can be treated as an organization. If its seen in this way, and the project manager creates a good culture, project team members and the project manager are more likely to want to work with each other again (participant 4).

6.4. Standardized project management practices for RE microgrids

The third research objective was to recommend standardized project management practices for the successful deployment of microgrids. The themes from both sets of interviews were project management tools and techniques, project success criteria, project management style and skills, culture and leadership. Project success criteria and project management style and skills have subthemes. Under project success criteria, the subthemes are project efficiency definition and project success definition. The subthemes under project management style and skills is communication, scope, stakeholder, resource, change, risk, time and financial management. Overall, the majority of the participants indicated that leadership has the greatest impact on improving project efficiency as it has the strongest influence on all the other identified themes. This is aligned with the greatest challenge identified in the ranking of challenges which was leadership and communication deficits.

Focusing on the recommendations under project management tools and techniques, it is clear that the overall sentiment from the participants is that existing methods (i.e. Waterfall method for the most part) for project management are on the whole sufficient for RE microgrid projects and that that there is benefit in applying methods not commonly used in the RE space such as Agile to improve on the shortcomings. This is yet to be more widely explored, and caution must be considered that project managers may be more open to incorporating unfamiliar methods if they are eased into it (use the unfamiliar methods together with existing methods). The recommendation for JIT for capacity building was deemed unsuitable by more than one participant which may introduce unnecessary risk in projects.

In terms of project success criteria, there was a consensus that a project is successful when the project objectives are met - completed on time, on budget and on scope at the right quality for the customer. This definition focuses more on the project deliverables and deadlines. The project team members must also agree on the metrics for successful completion. The project beneficiation must be clear to all stakeholders and safety requirements set out adhered to. The project efficiency measure is keeping to time for project delivery and resource usage is efficient i.e., waste is minimized as per the company requirements (since companies may have different metrics). It was important to gain insight into how to define project success criteria to standardize a definition.

Focusing on the subthemes under project management style and skills, the recommendations under scope management place emphasis on ensuring that scope creeps do not occur in projects. All the recommendations were deemed actionable for the South African context, but it must be noted that when trying to draw on learnings from other projects, it may be a challenge to solicit certain information from other completed microgrid projects as they are typically done in silos. The recommendations under

stakeholder management were also supported and emphasis was placed on community engagement. The recommendations under resource management, communication, risk management, procurement management, change management, time management, financial management, leadership and culture were also supported. The feedback from both sets of interviews show that the literature review findings closely align with participant feedback. It provides guidance as to the areas one can focus on to increase the likelihood of success of RE microgrid projects and it has shown that majority of the recommendations are actionable and are within the direct control of a project manager. Some limitations to note however are that the although the views of the participants are used to standardize the recommendations, it is limited to their input. Further work could include a larger and more diverse sample group in terms of profession and professional experience project management which may reveal requirements and challenges not identified in this study or alter the results in terms of what would impact likelihood of project success the most.

Although these recommendations were aimed at the South African context which is a developing country, there is value in considering if these would be applicable to developed countries and other developing countries. Approximately half of the world's population without energy access are located in Africa. Furthermore, majority of Africans without electricity access are rural populations (Onu, et al., 2023). This implies that it is highly likely that the recommendations that came from the findings in the research would be applicable to developing regions in Africa and other developing countries. Onu et al. (2023) study the drivers of microgrid projects both in developing and developed economies. Expanding energy access is the main driver in developing countries while emissions reduction, democracy (i.e., the rise of energy prosumers in microgrids) , energy security and resilience are the key drivers in developed countries (Onu, et al., 2023). It can be noted that there is a notable contrast between the priorities for microgrid roll-out between developed and developing economies. However, the recommendations for strong leadership and effective communication in project management would benefit both types of economies. In developed economies, to accelerate the priorities mentioned, microgrids are increasingly designed to be smart grids (i.e., the system has intelligent devices) and according to Onu et al. (2023) it is mentioned that social inclusion and sustainability be a central focus to achieve the 'smart' aspect. This is in line with the recommendation that community involvement is crucial for rural RE microgrids. Therefore, for developed countries there may be a need to tailor these recommendations for their context because their drivers for microgrid development differ from developing countries.

6.5. Contributions of research and limitations

The findings of this study show the significance of project management tools and techniques, project management skills, defining project success criteria , culture and leadership towards project success for RE microgrid projects. This research is applicable to project manager practitioners in the energy space (not just limited to the RE space), RE professionals, project developers and academics. Addressing the identified challenges and incorporating best practices can enhance project deployment efficiency in South Africa's renewable energy sector. The study was limited to project managers in the renewable energy space in South Africa and this focus is reflective of the central role that is played by project managers in project success and ease of accessibility of the sample group. Although the study would benefit from other relevant groups involved in project development such as community stakeholders for example, direct input was not considered in this study. Therefore, the findings focus heavily on the operational project aspects and less on other dimensions in RE project management. The main contribution of this research towards the problem statement is a set of tailored recommendations (which is currently limited in the research space especially for South Africa) that provide deeper insight into what would work well in the current South African energy industry considering the country's unique challenges. This research advances the knowledge in RE microgrid project management in South Africa by bridging the gap between commonly used project management frameworks and the practical realities of South Africa's renewable energy sector. Project managers in South Africa lean towards simple frameworks with RE microgrid projects which could be because exposure to project management training is limited. More exposure to project management frameworks through capacity building or formal qualifications may encourage professionals to consider using other frameworks that could improve project efficiency.

While the main elements of project success primarily focus on emphasizing adhering to scope, time, and cost, this study demonstrates that South African RE microgrid projects need an expanded focus on stakeholder engagement, capacity building, and continuous risk and quality management. The research has shown a possible imbalance in RE project management priorities (focus more on the iron triangle) than other important project management aspects.

In South Africa, the socio-political landscape heavily influences the extent to which risk management can effectively be carried out as with other developing countries such as India and Brazil. An example is given which is the construction industry which plays a key role in RE microgrid deployment. Therefore, thought must be given towards how to mitigate the influence of these external factors in when managing risk. The research has revealed that clear project definition is insufficiently addressed according to participant feedback. Inadequate definition can result in differing stakeholder expectations and therefore may impact

stakeholder buy-in. Insufficient capacity building is also a hindrance to successful projects – both in terms of a pipeline of skills in South Africa, the scope of skills transfer (mostly limited to technical skills) and experience in the field as found by literature. The complex stakeholder landscape in South Africa a contributor to leadership and communication deficits because each stakeholder group requires differing engagement approaches. Existing research has shown that stakeholder management amplifies risk management strategies so leveraging this link for South Africa would be beneficial to projects.

The research has revealed that there is a somewhat narrow definition of project success. Microgrids contribute to achieving energy access for all. Given that there is no universally accepted definition of energy access, project success can likely extend its definition by considering frameworks like the MTF to not only look basic electricity access, but evaluate other aspects like reliability, affordability and impact on user's health. Policy uncertainty and inconsistent implementation of legislation in RE space influences how participants viewed its importance in projects. Participants perceived governance/institutional structures as secondary since they prioritize immediate project factors more. This could indicate low trust with these institutions. Participants take a collaborative approach when forming plans for and doing projects but don't consider the associated skills meant for collaboration to be top of mind as important for project success. This is an interesting finding because it highlights a disconnect between perception and practice. It assumes that collaboration is natural skill that does not require intentional development.

Existing frameworks must be adapted to address socio-political complexity, regulatory uncertainty, and community dynamics in South Africa. It has been established that community participation is key to project success and sustainability. The level of participation is depended on social cohesion and in South Africa, the socio-political landscape results in varying levels of social cohesion. Therefore, this emphasizes the importance not just of community participation, but a level of community ownership which is highly likely to reduce resistance/sabotage to potential projects. The contribution of the research not only fills a knowledge base gap in the South African RE microgrid project management but also broadens the understanding of how global project management practices can be localized for the South African contexts marked by community complexities and policy uncertainty.

CHAPTER 7

CONCLUSION

This study provides an analysis of project management practices for larger scale renewable energy (RE) and RE microgrid projects in South Africa. Through a critical literature review and insights from two sets of semi-structured interviews, the study identified key successful practices, challenges, and requirements for RE microgrid project deployment. The findings emphasize the importance of leadership, communication, risk management, and community engagement as critical drivers of project success.

Project management frameworks such as PMBOK, CPM, CCPM, PERT, Waterfall, and PRINCE2 have been used in the RE space. Feedback from interview participants revealed that the Waterfall method is the most commonly used in South African RE microgrid projects due to its simplicity. However, its limitations, such as difficulty in accommodating changes, highlight the need for adopting more flexible project management to address these shortcomings. The study also shows the need for a gradual integration of new methods (such as Agile and Lean) to overcome resistance from project managers and project team members and ensure successful adoption.

Key requirements for successful microgrid project deployment include clear project definition, proper team selection, proper planning, and leadership. The findings show that leadership and communication deficits are the most significant challenges. Furthermore, adapting solutions to local contexts, proactive risk management and addressing community-specific needs are critical for ensuring project acceptance in South Africa.

The study's recommendations focus on standardized practices tailored to the South African context. These include defining clear success criteria, improving scope and stakeholder management, and using effective tools and techniques to improve project efficiency. The alignment between literature findings and participant feedback show the relevance and practicality of these recommendations. While the research provides valuable insights, it is important to note its limitations, including the relying on a specific sample group. Future research could expand the participant sample size to include a wider range of professionals and experiences, potentially identifying additional factors influencing project success. In conclusion, this research contributes to addressing the challenges of RE microgrid deployment in South Africa by offering actionable recommendations. These insights aim to enhance the efficiency and success of microgrid projects, providing a foundation for improving energy access and sustainability in the region.

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APPENDICES

5. Appendix A – Interview questions

Content validation questions

Q1: Do the questions effectively cover the purpose for which they are asked?

Answer 1: Yes. The questions are clear.

Q2: What other aspects can I consider asking the other experts?

Answer 2: Potentially including the aspect of the impact of the political landscape in South Africa. This definitely has an impact on the project management of rural microgrid projects. The issue of corruption and the impact on projects could be interesting but may be controversial to get answers from participants. The ethics angle is interesting as well.

Q3: Are the question appropriately challenging for senior level experts?

Answer 3:Yes, they are.

1. Interview questions and answers

1.1. General questions:

Q1: What is the position/role in the energy sector of the professional interviewed?

This question was relevant as it provides insight into the professional profile of the person being interviewed and sheds light on the suitability as a participant in this research.

Answer 1: From the eight (8) participants interviewed the range of professional experience noted includes:

- A senior researcher in energy modelling
- A senior researcher with focus on the Just Energy Transition
- A senior in power grid studies. The position held is managing director of an engineering consultancy firm in the energy sector that focuses on power system studies and renewable energy integration on the power system.
- A head of a technical division at their company that has to do with the procurement of renewable resources and other sources of energy. The company ensures that the technologies taken to the market to procure are up to industry standards and also does work where his company responds requirements of the country. The company also ensures technologies are aligned with the South African IRP (Integrated Resource Plan). Not only renewable technologies but everything at a utility scale as well.
- A senior researcher in power system design, power systems and planning with 12 years' experience. They are involved in modelling power systems and monitoring and evaluation work.

- A senior researcher in the energy industry currently which looks at the socioeconomics of the energy transition (moving from fossil fuels to renewable energies in South Africa). Their previous involvement was in the petrochemical industry as well.
- A senior energy expert whose work focuses on advocacy for the just energy transition (JET), bringing into the practical and systemic view of what the energy transition actually needs to make it 'just'. They is also part of the implementation of the decarbonization journey in the energy space particularly in townships in South Africa both in terms of deploying equipment and the implementation of renewable energy and microgrids. They also works to capacitate local stakeholders like local government, unions, businesses. She is also involved in enterprise development within the JET. This includes renewables, agriculture, water and other types of projects. Both assisting these organizations with non-financial and financial resources.
- A senior electrical engineer with experience in energy research (heavy current) and the transmission system of South Africa.

Q2: Reason for selection of participant

This question was relevant to highlight is the participants had relevant project management experiences regarding microgrid renewable energy projects (including other larger scale renewable energy projects) and project management qualifications/certifications. This was to get an idea of the types of projects they have been involved in and gauge the extent to which qualifications/certifications form part of the interviewed group.

Answer 2:

- For participant 1, project management experience has included mostly learning on the job, but no formal qualifications. Participant 1 has taken a short project management course in their career as well as a project management course which was taken in university. Short training courses were taken during work experience on basic project management.
- Participant 2 leads various energy research projects as a senior researcher primarily, but no formal qualifications and certifications.
- Participant 3 has a project management diploma. In terms of practicing, it at the current position, project management is done in close collaboration with programme managers at the company. Before this place, he had to manage several projects. Most work was done with consultants.
- Participant 4 does not have any formal project management certifications outside of trainings received on the job, i.e. applied fundamentals of project management. He attended a comprehensive course that trains on use of PMBOK. The focus was on the 11 topics of

PMBOK. Project management experience includes implementation of various projects the petrochemical space – related to the replacement of switchgears in substations; it was more planning, scheduling and risk analysis. Stakeholder identification and identifying affected parties for that particular project, get permits from them to ensure that they agree with what the project entails and also discussing the preliminary design that need that needed to be obviously costed and. An execution methodology developed that that addresses how the project will be rolled out. Specifically, in the renewable energy space is the microgrid implementation 200 kW project. Where he was involved with the construction and commissioning of a 200-kW microgrid for an industrial plant here. The designs were complete, and the role was to manage the construction, the contractors as well as the commissioning with the municipality. This particular project was connected to a municipal grid so needed to have alignment and considering the how the municipality sets up their plans in time. During the construction, they had to interface diesel generator with the grid as backup, battery storage and then solar PV all four sources to be interfaced and commissioned. There was no power export allowed back into the grid, so they had to look at how do they set that up so that they are able to ensure that that was not the case.

- Participant 5 has no formal project management qualifications or certifications, just experience gained working on the job. He has 19 years of experience in the energy sector.
- Participant 6 is involved in projects related to the just energy transition. She looks at the socioeconomic impacts of renewable energy projects. No project management certifications or qualifications. All experience was gained on the job.
- Participant 7 does not have any project management qualifications, but they did attend a course called project management fundamentals at a previous company they worked at. All other project management experience was gained through work experience.
- Participant 8 does not have any qualifications or certifications. They has on the job project management experience from various projects he has worked on in the space.

Q3: Gender

The participant group was balanced i.e., four seniors are male, and four seniors are female. This provides balance in terms of the inputs solicited and avoids gender bias in the answers received.

1.2. Part A: Familiarity and use of project management frameworks and tools used for renewable energy projects and RE microgrid projects

The first part of interview 1 focused on the familiarity and use of project management frameworks for renewable energy projects and RE microgrid projects. The questions that were included in Part A of interview 1 were:

1. What project management tool/frameworks have you more heavily used?
2. What have been the benefits and drawbacks of tools/frameworks that you have used?
3. What is the extent of collaboration amongst team members in managing the project, i.e. is the team's input into shaping milestones or delegating etc.?
4. What is your definition of a successful project?
5. How do you typically measure project performance?
6. Project efficiency can typically be defined through the dimensions of adhering to costs, adhering to the planned schedule, and adhering to project scope. How do you define project efficiency?
7. What do you think are key project management skills for a PM in the energy sector in South Africa?
8. Ranking the following compiled requirements from most to least important for successful RE microgrid projects in South Africa

Table A1: Requirements for successful project execution

• Clear project definition
• Technical skills
• Proper selection of project team members
• Information flow
• Sufficient and suitable resources/tool availability for project management
• Project governance
• Quality assurance
• Culture and leadership of the project manager (environment that they create)
• Identify business case
• Proper project planning and project parameters
• Cooperation with implementation institutions
• Project manager assignment and their managerial skills

- **Part B - Gaps and challenges regarding project management in renewable energy microgrid deployment in South Africa**

The second part of the interview 1 focused on the gaps and challenges regarding project management in renewable energy microgrid deployment in South Africa. The questions that were included in Part B of interview 1 were:

1. Considering the project management life cycle, what main project management challenges have you experienced as a project manager in South African renewable energy projects and specifically with rural RE microgrid deployment:
    a. In the initial/initiating phase?
    b. In the planning phase?
    c. In the executing phase?

d. In the monitoring and controlling phase?
e. In the closing/final phase?

2. From the requirements mentioned, what do you think is not being sufficiently addressed in South Africa and how has this affected overall project efficiency?
3. Typically, does your involvement conclude after commissioning a microgrid or have you still been involved in the operation of the microgrid/s? Please elaborate on the extent of involvement.
4. What do you think are key project management skills for a PM in the energy sector in South Africa are missing?
5. What other project management challenges not mentioned do you think may arise as more renewable energy electrifies rural villages?
6. Ranking the following compiled challenges from most to least challenging regarding RE microgrid projects in South Africa

Table A2: Challenges experienced during RE microgrid projects

• Mismanagement, lack of commitment from project managers
• Leadership and communication deficits
• Key Decision-Making by Main Management (strategic management)
• Lack of expertise/experience in managing renewable energy projects
• Technical expertise of project team
• Project scope challenges (both managing and adapting to scope)
• Adapting solution to local contexts

Second set of interviews: Recommended project management practices to be practically implemented in South Africa

The set of questions that formed part of the second set of interviews were:

1. From the established themes, what do you think will impact project efficiency the most and why?
2. What is the suitability of implementing these recommendations in South Africa and what practicalities must be considered for rural South African communities?
3. What barriers may stand in the way of implementing these recommendations in South Africa?

6. Appendix B: Code development and participant ranking

1. A priori code development

Table B1: Code development for challenges in renewable energy project management

Code	Themes
Key decision making by main management	Leadership
Too large a scope for projects	Scope management
Low level of knowledge regarding RE project management	Project management skills
Information flow in projects	Communication
The geographical dispersion of rural sites for microgrids makes communication difficult	Communication
Adaptability to local contexts	Adaptation a solution to local contexts
Lack of community engagement	Stakeholder management
Lack of community support	Stakeholder management
Community engagement post commissioning of a project becomes minimal	Stakeholder management
Need for improved stakeholder management	Stakeholder management
Management of changing consumer habits was challenging	Stakeholder management
Lack of strong commitment of project managers	Leadership
Lack of a performance management system/s and benchmarks for monitoring progress	Project performance measures
A lack of clear direction/leadership from project managers	Leadership
Lack of experience/competency skills in project managers	Project management skills
Skills deficit in project team members	Project team skills
Ability of the project manager to assemble of the project team with suitable technical expertise	Project team selection
Project managers are not equipped with adequate skills set and competence	Project management skills

Table B2: Code development for successful practices in renewable energy and renewable energy microgrid project management

Code	Themes
Project activities (scoping)	Scope management
Developing project schedules and cost estimation.	Time management and financial management

Likelihood of achieving project goals/success, is increased by performing risk analysis	Risk management
Risk must be dealt with proactively	Risk management
Managing a change in consumer habits Holding workshops about the technologies in the microgrids	Stakeholder management
Close social engagement with communities at throughout the project stages	Stakeholder management
Comprehensive project planning and development	Project planning
Local government support	Stakeholder management
Active participation from the community	Stakeholder management
Maintenance scheme, suitable technicians and suppliers	Project planning

Table B3:Code development for requirements in renewable energy microgrid project management

Code	**Themes**
Identify business case	Project planning
Clear project definition	Project planning
Closing the Project	Project closure
Defining success factors for RE projects	Project success criteria
Consistently monitor the success factors	Monitoring and control
Proper selection of project team members	Leadership
Management of human resources	Leadership
Sufficient and suitable resources/tools availability	Project management tools and techniques
Project manager assignment/managerial skills	Project manager skills
Proper project planning	Project planning
Information flow	Communication
Strategic management	Leadership
Cooperation with implementation institutions	Stakeholder management
Technical skills related to plant outage and local site knowledge	Technical skills
Project management qualification/s or certifications were also identified as a benefit but not requirement	Project management skills
Project governance	Leadership
Positively influence team members	Culture
Project parameters	Project planning
Quality assurance	Quality management

2. Part A - Familiarity and use of project management frameworks and tools used for renewable energy projects and RE microgrid projects

Table B4: Part A, Question 1 and Question 2 code development

Participant	Question 1: What project management tools/frameworks have you more heavily used?	Question 2: What have been the benefits and drawbacks of tools/frameworks that you have used?
Participant 1	"Waterfall method"	"Control in managing the project" "Prioritize activities" "Time overruns and cost overruns" "Resources can get constrained" "Aren't really measures to ensure resources get levelled"
Participant 2	"PMBOK in managing projects"	"Internationally recognized framework" "Introduces a level of standardization" "Makes it easier to communicate" "Do have room to address project specific needs" "It is not rigid in your implementation" "PMBOK does emphasize the importance of risk management" "PMBOK is a bit complex for new project managers" "Which can potentially overshadow the importance of interpersonal skills and team dynamics"
Participant 3	"Microsoft Project' "Own project management tools using Microsoft Excel" "Critical Path Method"	"Critical Path Method to track resources and mitigate risks" "Microsoft project allows you to minimize errors" "Forces you to think critically about every task" "Gives a good view of the project[Microsoft Project]." "Invest time upfront to properly plan your project using Microsoft project" "If there is no consultation with the team the tool becomes ineffective."

Participant 4	"PMBOK that has been applied extensively"	"It [PMBOK] gives a wholistic understanding of the different aspects" "Provides good coverage of what the project management process entails" "PMBOK is quite lengthy and comprehensive" "PMBOK for low complexity is a bit overrated"
Participant 5	"Sequential/waterfall planning of activities, project schedules and timelines"	"Sequential methods appear sufficient" "Other methods such as PMBOK may be overkill for microgrid projects."
Participant 6	"Microsoft Excel is used quite often." "Another internal company tool is used as well to do scheduling"	"Relatively easy to use" "Part of the project is not in your control; this is not reflected in the tool"
Participant 7	"SAP Plant Maintenance or SAP PM" "Microsoft Excel in other companies (using the macros in Excel)."	"Microsoft Excel is easy to work with" "Good visualization of what you'll be doing. " "Excel macros cannot optimize resource loading"
Participant 8	"Project management lifecycle used when managing projects" "Sequential/waterfall process"	"Every phase that you move in, you know you have approvals for every step at the company. You have a sufficient budget to ensure you have the resources you need to do the project" "From a research point of view, it causes a lot of delays in projects" "Project management method used does not appear to properly align with the company processes"

Table B 5: Part A, Question 3 and Question 7 code development

Participant	**Question 3:What is the extent of collaboration amongst team members in managing the project, i.e. is the team's input into shaping milestones or delegating etc.?**	**Question 7: What do you think are key project management skills for a PM in the energy sector in South Africa?**
Participant 1	"With more resources, collaboration and delegation is easier" "Leadership style is more authoritative with fewer resources"	"Know the core of the work you're doing" "Negotiating skills" "Know political landscape in South Africa" "Financial management" "Good knowledge of your stakeholders" "Time management" Not only to ensure you complete on time, but also because of the relevance of the research" "Language skills"
Participant 2	"Whole team to be involved right from conceptualization" "Having team involvement ensures that resources are able to meet deliverables and what is manageable" "Inputs at beginning, inform timelines"	"Interpersonal skills" " Leadership skills" "Motivate and guide the team" "Communication skills" "Time management skills" "Risk management skills important" "Budget management skills" "Negotiation skills"
Participant 3	"You can have a high-level structure of activities and time, and resources needed" "Take high level structure to the entire team and get their input to jointly develop the project schedule"	"Regulations that have to do with stakeholder engagement" "Financial management skills" "Utilizing tools for project management"

	"With different disciplines e.g. mechanical engineers, geotechnical professionals, engaging them and building the milestones and schedule jointly is important" "Easier to spot risks in the project and mitigate accordingly"	
Participant 4	"His style is more inclusive even though he does not expect contributions from others" "His project management style changes with the colleagues he works with based on cultural differences"	"One must be very adaptable" "You need to have a good appetite for risk" "Open to changes"
Participant 5	"His project management style is doing a schedule with the project team, and brainstorm with them."	"One needs to understand the energy landscape" "Change management is important because of the novelty of renewable energy."
Participant 6	"Everybody's input is valuable in shaping milestones and planning"	"People skills" "Basic financial literacy" "Technical knowledge of the project you manage"
Participant 7	"People involved in the proposal should be involved in doing the plan." "Prefers collaboration from the very start"	"Proper stakeholder management." "You need a good background of energy, key trends and key happenings in the sector"
Participant 8	"Focuses on good relationships with resources especially when they are constrained."	"Technical skills are key." "Financial management is necessary (things like accounting)."

		"Recognize skilled resources when selecting these for projects"

Table B6:Part A, Question 4, 5 and Question 6 code development

Participant	**Question 4:What is your definition of a successful project?**	**Question 5: How do you typically measure project performance?**	**Question 6: Project efficiency can typically be defined through the dimensions of adhering to costs, adhering to the planned schedule, and adhering to project scope. How do you define project efficiency?**
Participant 1	"Scope must be delivered as requested, on budget and on time"	"Planned tasks and actual work that has been done [scope is met]" "[Via] Milestones and when they are achieved" "Customer is happy"	"Project efficiency is defined according to keeping to scope, budget and time and measured during the project." "Measured by resource utilization"
Participant 2	"If the project meets the clients' needs, it is completed within an acceptable budget, scope and timelines"	"If the project meets the clients' needs, it is completed within an acceptable budget, scope and timelines"	"Adhering to costs, adhering to the planned schedule, and adhering to project scope"
Participant 3	"Deliver scope of work as prescribed at the desired quality"	"Cost, quality and key milestones"	"Project efficiency can be discussed in terms of the relative effect it has on the overall organization."
Participant 4	"Textbook definition of a successful project is within budget, schedule and cost"	"It is purely based on the project management	"Emphasizes delivery on time being the standout on efficiency."

	"All the risks were managed accordingly." "Feedback as well from the project team also counts toward success." "It [success of the project] is also measured in terms of beneficiation of the project"	team's satisfaction." "If the PM is proud, then it is a sure indication that it is performing well"	
Participant 5	"Initial project objectives are met that were put forth by the project owner" "Deliverables met, done within time and budget."	"Performance of the project is based on the performance of the people doing the project" "Quality of the deliverable is of a high standard"	"Time is the efficiency measure."
Participant 6	"The project is done on time, on budget and meets the main objectives of what it was set out to do"	"Project performance measure: if the project is done on time, on budget and meets the main objectives of what it was set out to do"	"Project efficiency is minimizing wasteful expenditure and wasting time."
Participant 7	**"**When a project is on budget, on time and on brief." "Quality needs to also be of a high standard"	"If the project is of the right quality, customer expectations are met and the	"By the usage of resources and the competence of human resources" "Efficiency is therefore also to get the best quality for the least amount of

		project is on time, on budget and on brief"	money with the most competent resource/s possible"
Participant 8	"A successful project is one where the user requirements are met." "One must also make sure that everything is done within the budget and timeframes set." "The quality of the work should be of a high standard."	"Project performance is based on the requirements of the project."	"If the project is late and of poor quality or if too much is spent on resources or an unforeseen expenditure on resources then it is inefficient"

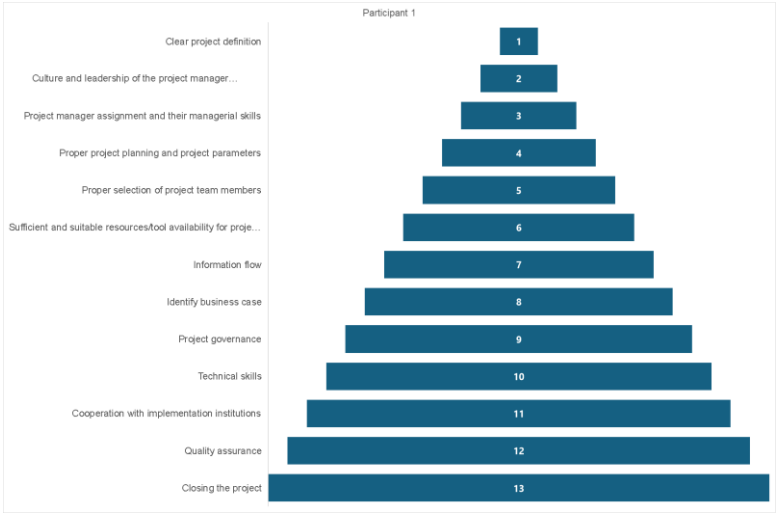

Figure B1: Participant 1 ranking

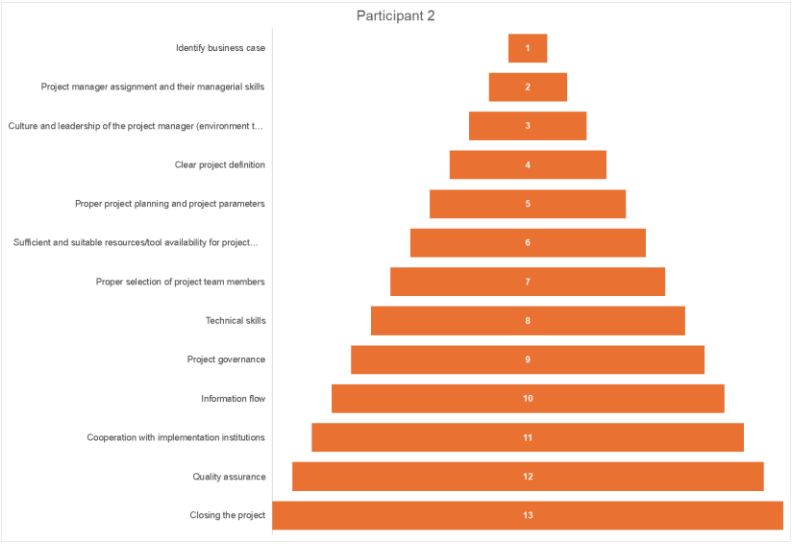

Figure B1: Participant 2 ranking

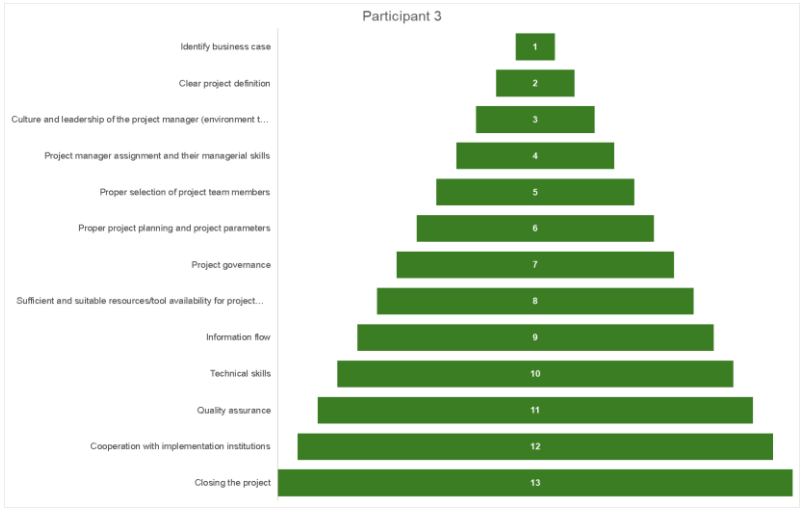

Figure B2: Participant 3 ranking

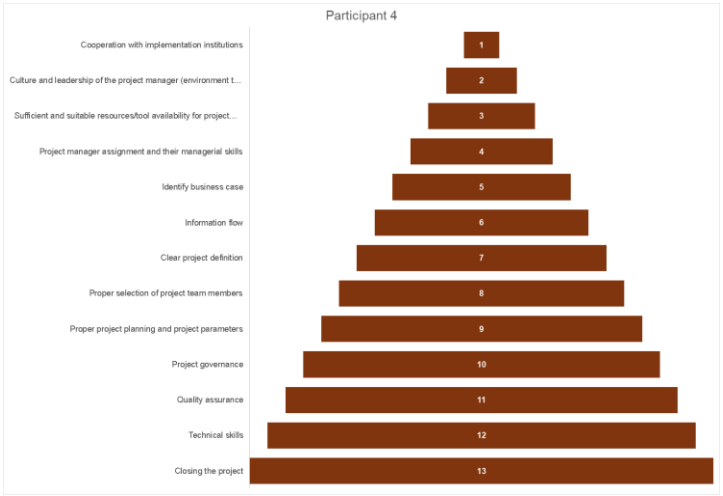

Figure B3: Participant 4 ranking

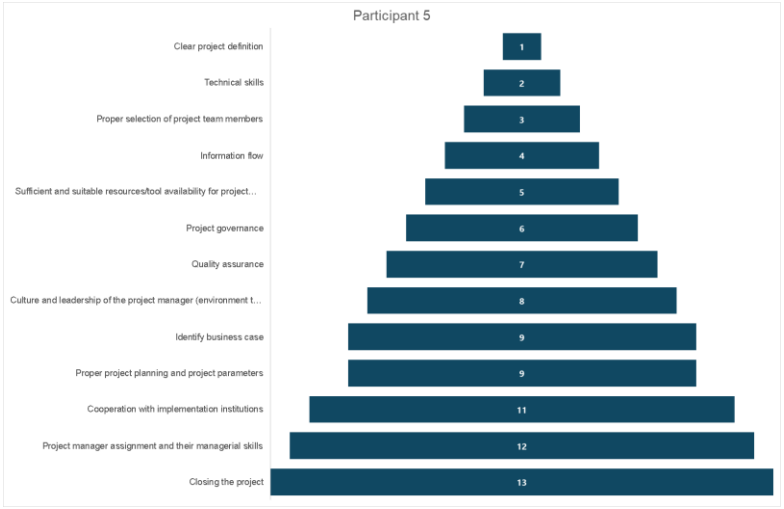

Figure B4: Participant 5 ranking

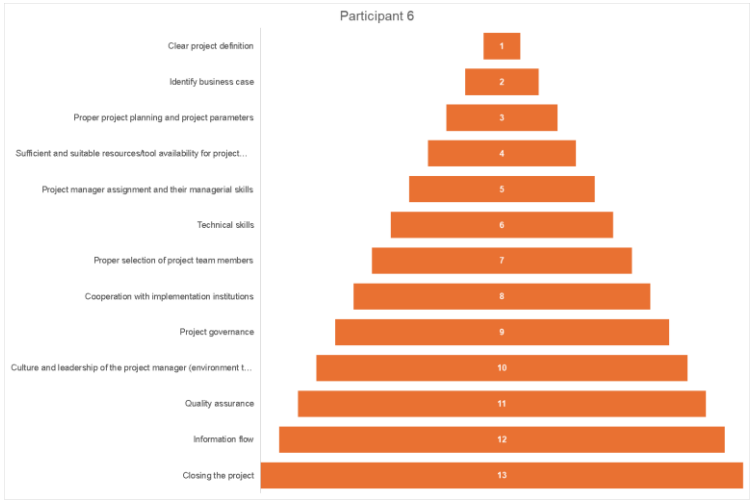

Figure B5: Participant 6 ranking

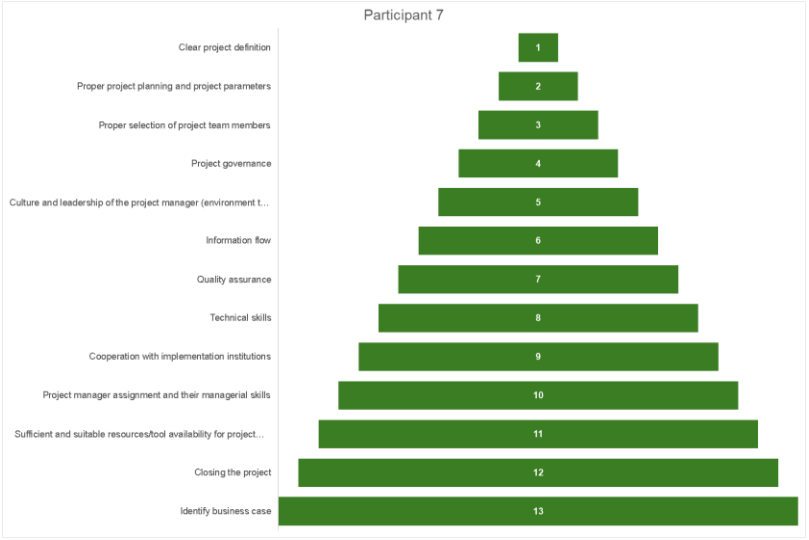

Figure B6: Participant 7 ranking

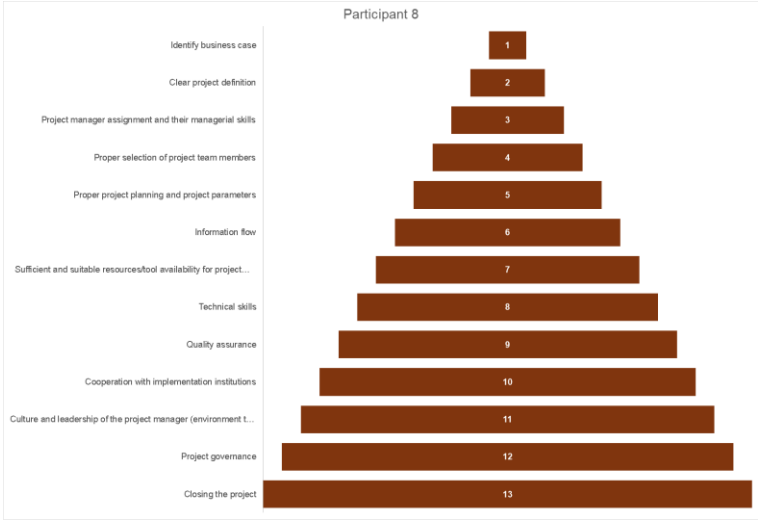

Figure B7: Participant 8 ranking

1. Part B - Gaps and challenges regarding project management in renewable energy microgrid deployment in South Africa

Table B7:Part B, Question 1 code development

Participant	Question 1: Considering the project management life cycle, what main project management challenges have you experienced as a project manager in South African renewable energy projects and specifically with rural RE microgrid deployment:				
	In the initiating phase?	**In the planning phase?**	**In the executing phase?**	**In the monitoring and controlling phase?**	**In the closing/final phase?**
Participant 1	"Stakeholder engagements" "Challenge is that people are not well informed, so resistance to proposed project is experienced"	" Data collection can be challenging" "Resource allocation is a big challenge" "Works with a lot of assumptions - these can sometimes be incorrect for the project" "Resources planned for are insufficient"	"The cost overruns are an issue as well." "Scope creeps as well"	"If performance measures are not clearly defined it makes monitoring a challenge" "In terms of control, if you don't do risk analysis in the planning stage, control becomes difficult"	"Exhaustion/fatigue" "Documentation happens here, and lessons learnt about things that went right/wrong to be better prepared for the next project. This can be rushed just to finish the project."

Participant 2	"Poor scope definition" "Poor identification /estimation of the costs" "Poor communicati on with the external stakeholders initially"	"No proactive risk identification , assessment and management upfront"	"The scope was redefined several times during execution"	"There was no plan in place for monitoring"	"Handovers were not smooth" "There was no performance reporting put in place towards the end of the project" "Resourcing/bud geting towards the end; they were constrained"
Participant 3	"One challenge is the issue of making sure you have a clear business case" "A microgrid tends to be 'nice' idea that is liked" "Many business cases are not sustainable financially"	"Make sure you have the proper tools and the required technical aspects of what you need to implement is done properly" "Proper engagement with stakeholders from the planning stage already"	"Aspects that speak to your communicatio n strategies in place"	"Risks that you've identified upfront and how to deal with this" "Risk management strategies and communication strategies"	"Some don't do a 'lessons learnt' and closing documentation"

Participant 4	"A lot of work that needs to be done in community engagement" " Managing expectations can be a challenging aspect"	"Key to identify the right people to provide input to the planning stage"	"Dealing with contractors can be quite a challenge" "One really needs contract management skills" "Having a good understanding of client expectations"	"What value does monitoring, and evaluation have for the user?" "You become a nuisance when requesting feedback"	"Tracking how you have been documenting project activities" "How the project manager enforces the document control"
Participant 5	"Project definition and scoping of the project is a challenge"	"If scoping was not done well, planning the project is a challenge. "Allocation of tasks and resources becomes challenging."	"Typically, with microgrid projects one does not have a benchmark. People get uncomfortable in the face of new knowledge and turning that into practice." "In developing Africa there is an ethos of no/lack spirit of pioneering" "Time management is an issue."	"When there are no control processes in place, time delays may have a domino effect" "Discipline in the project as well"	"If the recipients are not open to change, the project can be poorly received." "Lack of confidence to close out properly."

Participant 6	None.	None.	"Implementation is sometimes when things go wrong"	"If there's no M&E framework then a project can fail"	"The people to whom it will be handed over to it may not always be clear to them the benefits of the project or how it will benefit their lives."
Participant 7	**"**Conceptualization"	"Selecting the best resources for the project." "Linking your activities strongly with the conceptualization."	"Working with diverse teams sometimes"	"If you do not have a monitoring plan and information flow is poor, then it will negatively impact the project."	None
Participant 8	"Convincing investment committees that a project is in line with the organization's objectives."	"Data collection" "Sometimes one needs to work around security issues with accessing the data"	"Procurement of equipment can be quite a challenge" "Another challenge is a finding the right skills to implement"	None	"One of the main challenges is about getting the information and documents compiled for ease of reference for those who require it"

Table B8: Part B, Question 2, Question 4 and Question 5 code development

Participant	Question 2: From the requirements mentioned, what do you think is not being sufficiently addressed in South Africa and how has this affected overall project efficiency?	Question 4: What do you think are key project management skills for a PM in the energy sector in South Africa are missing?	Question 5: What other project management challenges not mentioned do you think may arise as more renewable energy electrifies rural villages?
Participant 1	"Pipeline of skills" "All of the skills we don't have locally, and we have to outsource."	"Project governance is lacking" "Leadership is lacking in projects" "Cooperation with implementation institutions could be better addressed" "Resource allocation could be better planned out" " Resource management is lacking" "Projects fails also because things take a long time to arrive" "Risk management needs to be improved"	"Engaging with the community provides the best direction"
Participant 2	"Identifying the business cases in South Africa is a challenge" "Clear definition of projects is in South Africa is a challenge" "The above are problems because microgrids must be sustainable in the long term" "With one of the microgrid projects, there was no	"Interpersonal, leadership, communication, risk management" [are missing skills]	"Linguistic skills to connect with communities"

	communication with the provider and a municipality. The stakeholders were not aligned"		
Participant 3	"Proper selection of team members – sometimes not done well in South Africa" "Skills are not suited to the project sometimes"	None.	"There must be a good structure for community ownership"
Participant 4	"They [cooperation institutions] do have the power to put a project to a complete halt." "A project manager has PMP for example, but these skills are not just easily transferrable." "Need relevant experiences to apply it to the renewable projects." "Project managers need to understand the roles of the project team"	None.	"A shortage of capacity in terms of the number of skilled project managers"
Participant 5	"Leadership issues given that it's a relatively new space"	"Lack of advocacy of the spirit of pioneering and being trendsetters and leadership."	None.
Participant 6	"Lack of proper communication and awareness for key stakeholders." "A deeper technical understanding is required for project managers"	"Social experts or expertise will be vital."	"Community awareness and strategies to achieve this become more crucial."

Participant 7	"Clear project definition is one of the main challenges in the South African context" "Information flow: Project managers struggle with this." "Sometimes technical skills: Dependent on skills available to the company"	"Conceptualization and having the right planning related to the project."	"If people are going to be leaving rural villages that do not have the skills to know what is happening with projects deployed there it will be very bad because there will be no monitoring to ensure that the projects reach their expected life."
Participant 8	"Technical skills are not being sufficiently addressed."	"Financial management skills and technical skills"	"Communication with these communities"

Table B9: Part B, Question 3 code development

Participant	**Question 3:Typically, does your involvement conclude after commissioning a microgrid or have you still been involved in the operation of the microgrid/s? Please elaborate on the extent of involvement.**
Participant 1	None.
Participant 2	"No experience post commissioning but insight can be gained about opportunities engaging with communities post commissioning"
Participant 3	None.
Participant 4	None.
Participant 5	"Yes, to a certain degree. A few projects where you find monitoring and evaluation that is done"
Participant 6	"Experience in a previous job. About 40 % of the job involved monitoring and evaluation plans of deployed energy projects"
Participant 7	"Yes, in a previous company she did this for a project for a good two years after a project concluded to monitor the operation of two microgrids. They did remote check in on the operation from meters"
Participant 8	"Current company has a microgrid commissioned in 2017. Focus was maintenance work."

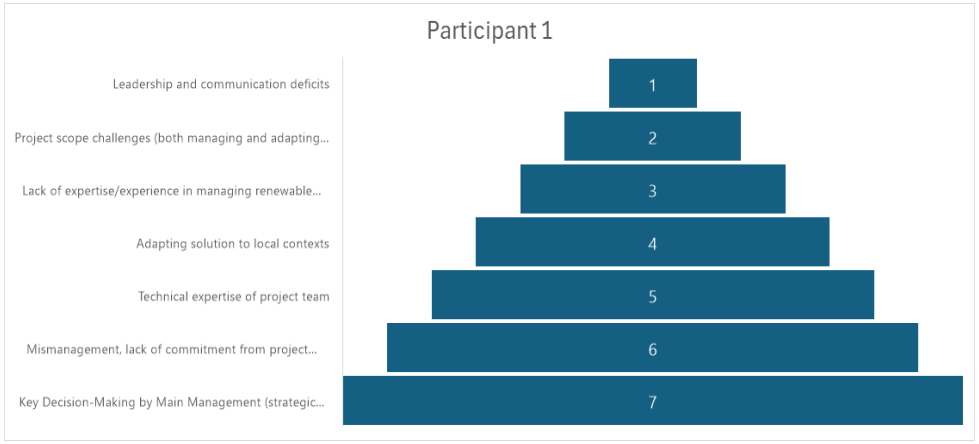

Figure B 8: Participant 1 ranking

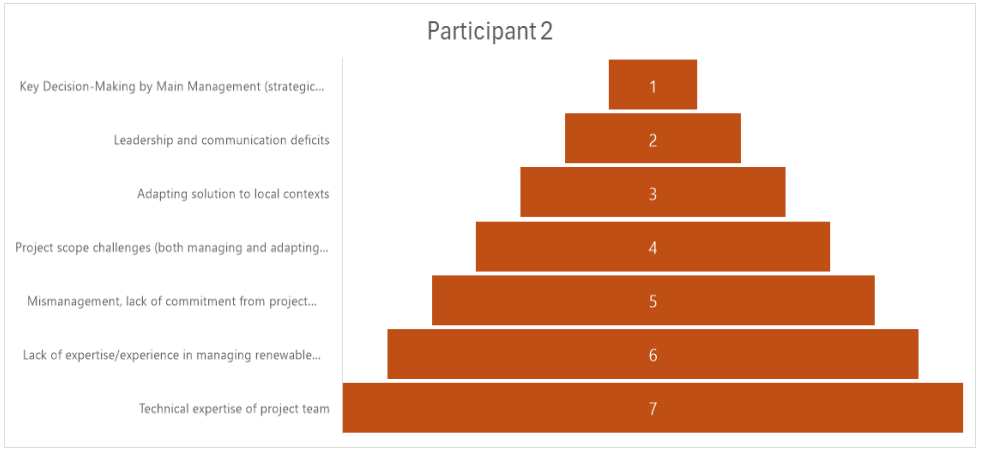

Figure B 9: Participant 2 ranking

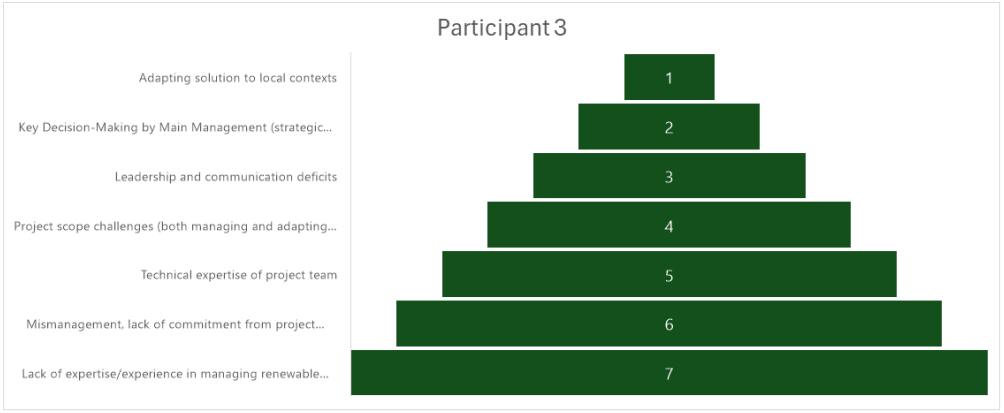

Figure B 10: Participant 3 ranking

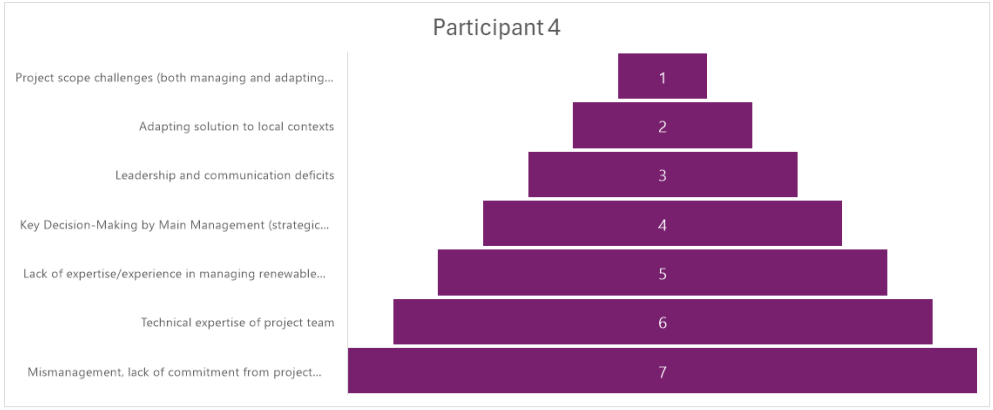

Figure B 11: Participant 4 ranking

Figure B 12: Participant 5 ranking

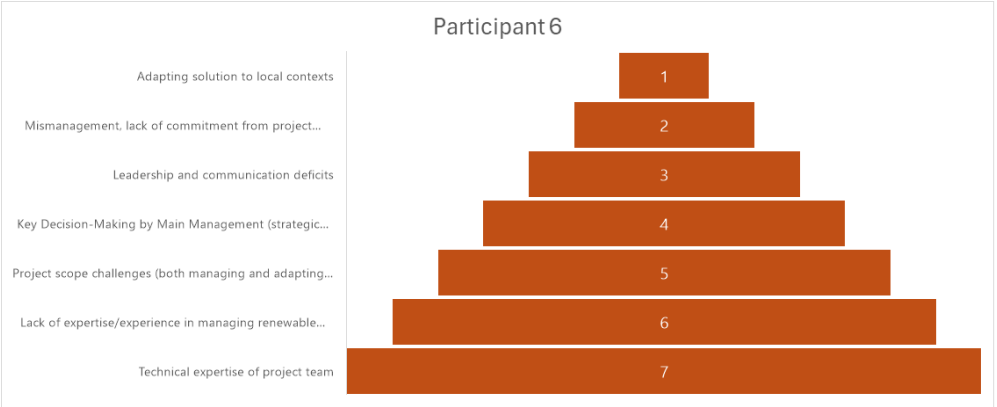

Figure B 13: Participant 6 ranking

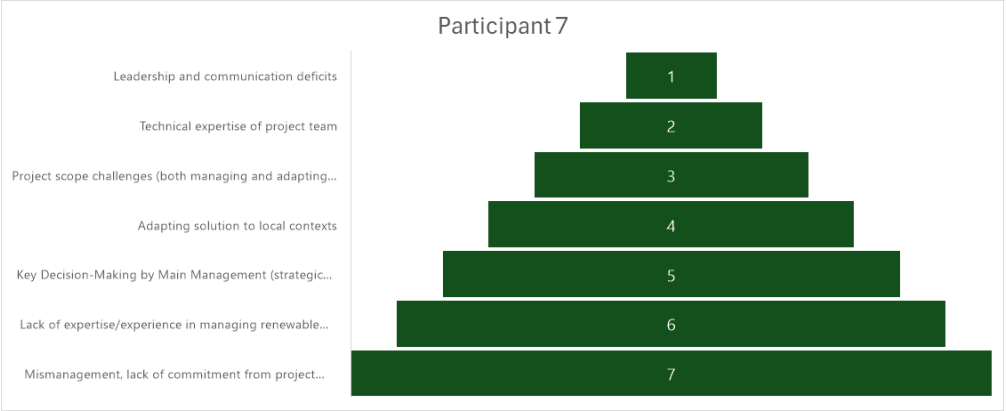

Figure B 14: Participant 7 ranking

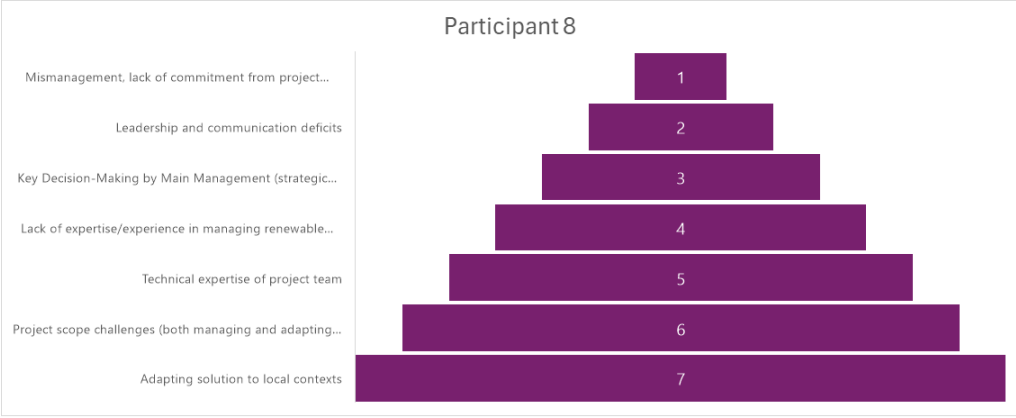

Figure B 15: Participant 8 ranking

7. Appendix C – Second set of interviews feedback – Question 1

Table C1: Question 1, second set of interviews

Question: From the established themes, what do you think will impact project efficiency the most and why?	
Participant	Feedback
1	Leadership. Projects tend to have a lot of people involved. If the leadership is not good in terms of consolidation, it will not have sound direction.
2	Project management style and skills. Scope management and communication (effective communication with the project team) and risk management are the top three largest influences. The other factors under project management style and skills are a subset of the scope management. If you manage your scope well, then you should not have time management issues for example. Proper scope management means that resources would also be adequately planned. Risk management should be continuously done, so that you are not running over time or budget and proactively identify the things that might impact your scope.
3	Leadership. The other items is indecisive, a lot of things can be delayed, and the project would come to a standstill. In procurement at a country level, the leadership at the top just dropped the ball, and this affected procurement during the previous REIPPP bid window.
4	Project management style and skills. That's where you can give project manager the tools and techniques, but if they don't know how best to apply them, then its highly likely that the project will not succeed. If you have well experienced project managers who adopt a certain style and are able to demonstrate their skills very well in projects, then there's a good chance of a project succeeding. Stakeholder management is very key and change management. In the South African context, most of the projects are undertaken with stakeholders, who themselves don't always have clear expectations. Their expectations may change along the way during a project, and this would touch on change management as well. As a project manager how is this change handled?
5	Project management style and skills. Sometimes you can have tools and techniques but if you don't have the right people to implement them then they can be useless.
6	Leadership. All the others will work well if the correct leadership is in place, or they can guide the processes.
7	Culture. That is made up of having accountability, KPIs or manage performance in that way. Meetings being out-put driven and role modelling – How you want others to be. That does indirectly impact project efficiency and have a huge impact on project success.
8	Leadership. Because if you're in an environment with multiple projects, the leader chosen must be able to assist those below them. It is based on experience which a leader has.