THE ROLE OF THE LOCAL GOVERNMENT SECTOR IN PROMOTING RENEWABLE ENERGY AND THE IMPLICATIONS ON SKILLS DEVELOPMENT

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EXECUTIVE SUMMARY

As the world groans under the effect of global warming, it becomes obvious that sourcing alternatives to fossil fuel, which is one of the causes, is no longer an option. In light of this, all hands must be on deck to fight the common enemy. In the context of South Africa, local government – as one of the arms of government and the closest to the grassroots – plays a critical role in the transition from being fossil fuel dependent to relying on a low-carbon generated environment. Thus, reducing GHG emissions, adopting renewable energy, improving energy security, and advancing sustainable energy development in South Africa requires active participation and promotion from local governments. Local government has the statutory responsibility to effect some of the changes needed for this transition. However, little has been seen in this regard. The Municipal Systems Act (2000) gives local governments the right to set up a department to oversee and run sustainable energy provision. Unfortunately, most local governments in South Africa have yet to harness this potential. They are either deficient in capacity, resources, or implementation. This report reviews the role of local government in the promotion of renewable energy in South Africa. The review is based on various relevant scholarly works on local governments and the field of renewable energy.

Understanding the role of local government in promoting renewable energy is critical to determining how it promotes renewable energy initiatives or projects within its jurisdiction. The review explored local government involvement in renewable energy in terms of policy development, implementation, and regulations. For instance, local governments are expected to develop policies that prioritise and promote the use of renewable energy sources and create a favourable environment that attracts renewable energy industries, which in turn leads to increased job opportunities and grows the economy of the municipality. Policies such as tax holidays and subsidies are viable ways of encouraging investment in renewable energy at the community level. Additionally, policies on partnerships with private individuals and organisations regarding renewable energy ventures are essential. More importantly, community engagement offers many benefits in terms of renewable energy initiatives and projects as local governments educate the communities through regulations on public awareness campaigns and outreach programmes. This involvement creates a sense of ownership and promotes acceptance. Thus, the projects within the municipalities are protected and secured.

Furthermore, the review examined the technical and environmental feasibility of implementing renewable energy systems in local municipalities. Transitioning into a green energy economy is complex and, as such, depends on parameters such as technological development, economic viability, social acceptance, and an enabling environment for sustainability. Various

technologies are critical for supporting renewable energy at the municipal level. For instance, green hydrogen, wind energy, hydro, biomass, solar, wind, and concentrating solar thermal power are all examples of renewable energy sources. Thus, the review concentrated on these technologies and how local governments offer technical assistance and support to residents and businesses for installing renewable energy systems while ensuring proper design and installation. Similarly, investment in technical training to build capacity among the staff and the youth within communities was considered, as this has been identified as a way of reducing and eliminating technical skills shortages in the municipalities.

Successful renewable energy initiatives and projects at international and regional levels have been examined while considering how these successes can be adopted and replicated in South Africa. Countries like Germany, Japan, Denmark, and the USA were studied in conjunction with best practices from the Southern African Development Community (SADC) countries, and lessons for South Africa were drawn. Factors such as community-based projects, eco-models, transition towns, public-private partnerships (PPPs) through a policy framework, institutional arrangement, capacity building, and education were identified as potential solutions. In addition, promoting renewable energy initiatives in sectors and using waste-to-energy options to convert organic waste into biogas or biofuels, reducing landfill waste, and producing energy were also described.

However, in the process of the review, several issues were raised that must be addressed to ensure that local government participates in the renewable energy field. Thus, local governments must establish clear renewable energy policies and integrate them into their development. They must also have renewable energy policy targets to ensure implementation and monitor achievements. Likewise, local governments should heavily invest in technical training to enhance capacity among both staff and the youth in communities. In addition, knowledge sharing and collaboration among local governments on successful renewable energy initiatives or projects must be encouraged. Likewise, international best practices must be studied and applied in South Africa.

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DEFINITION OF TERMS

Capacity: is the 'how' of development – "it is about strengthening the capabilities of people and the institutions so that they are able to efficiently and effectively meet the objectives, adapt to change and be resilient…" (Reddy, 2014:2).

District Development Model: an operational model for enhancing cooperative governance, designed to develop an ethical and well-capacitated developmental state where performance is higher and there is accountability for effectual and coherent service delivery outcomes (COGTA, 2022).

District Municipality: a Category C Municipality with municipal executive and legislative authority in an area with more than one municipality, as defined in section 155 1 (c) of the Constitution (1996).

Local Government: the third sphere of Government in South Africa as detailed in Chapter 7 of the Constitution (1996).

Local Government: Municipal Structures Act 177 of 1998: provides for the establishment of categories/types of municipalities; the division of powers/functions between categories of municipalities; regulates the internal systems, structures, and office bearers of municipalities; and stipulates the municipal electoral system to be used.

Local Government: Municipal Systems Act 32 of 2000: focuses on the core principles/mechanism/processes to facilitate the socio-economic upliftment of communities; establishes a regulatory framework for municipalities to perform their functions and exercise their executive authority; prescribes the processes underpinning developmental local government namely public participation, integrated development planning, and performance management/reporting, resource allocation and organisational change.

Local Municipality: a Category B Municipality that has municipal executive and legislative authority in an area that has more than one municipality, as defined in section 155 (1) (b) of the Constitution (1996).

Renewable Energy: energy from renewable resources that are naturally replenished on a human timescale. These include sunlight, wind, the movement of water, and geothermal heat.

Skill Development: the productive capabilities acquired through all levels of learning and training, occurring in formal, non-formal, informal and on-the-job setting.

LIST OF ACRONYMS

AMEU	Association of Municipal Electricity Utility
ARDL	Auto Regressive Distributed Lag
ARX-GARCHX	Autoregressive Conditional Heteroskedasticity (Arch)
CCA	Community Choice Aggregation
CDM	Clean Development Mechanism
CGCSA	Consumer Goods Council of South Africa
CGE	Computable General Equilibrium
COGTA	Corporate Government and Traditional Affairs
CSIR	Council for Scientific and Industrial Research
CSP	Concentrated Solar Thermal Power
DALRRD	Department of Agriculture Land Reform and Rural Development
DBE	Department of Basic Education
DEDEAT	Development Environmental Affairs and Tourism
DHET	Department Of Higher And Tertiary Education
DFFE	Department of Forestry, Fisheries and the Environment
DMM	Digital Maturity Model
DMRE	Department of Mineral Resources and Energy
DNI	Daily Natural Irradiance
DRES	Decentralised Renewable Energy System
DSI	Department of Science and Innovation
DTICC	Department of Trade Industry and Competition
EAI	Energy Awareness Index
EIA	Environmental Impact assessment
EMC	Eco-Model City
EPSTEIN	Environmental Policy Simulation Tool for Electrical grid Interventions

ESI	Electricity Satisfaction Index
EWSETA	Energy and Water Sector Education and Training Authority
FDI	Foreign Direct Investment
FIT	Feed-in Tariffs
GARCH	Generalised Autoregressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
GHGs	Greenhouse Gas
GIZ	Gesellschaft für Internationale Zusammenarbeit
HEMS	Home Energy Management System
HVDC	High Voltage Direct Current
ICLEI	International Council for Local Environmental Initiatives
IEA	International Energy Agency
IGR	Internal Generated Revenue
INEP	Integrated National Electrification Programme
IPPs	Independent Power Producers
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan
ISO-NE	Independent System Operator New England
JBI	Joanna Briggs Institute
JET-IP	Just Energy Transition Investment Plan
LCC	Line Commuted Converter
LCOE	Levelized Cost of Electricity
LED	Local Economic Development
LFGE	Landfill Gas Energy
LGSETA	Local Government Sector Training and Education Authority
MENA	Middle East and North Africa

METI	Ministry of Economics Trade and Industry
NDP	National Development Plan
NEMA	National Environmental Management Act
NEMAQA	National Environmental Management Air Quality Act
NERSA	National Electricity Regulator of South Africa
NGO	Non Governmental Organisation
NPC	Net Present Cost
NRF	National Research Framework
NUMSA	National Union for Metalworkers South Africa
NWP	Numerical Weather Prediction
OECD	Organization for Economic Cooperation and Development
PPAs	Power Purchase Agreements
PPGI	Public Private Growth Initiative
PPPs	Public Private Partnerships
PV	Photovoltaic System
RDI	Research Development and Innovation
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Procurer Procurement Program
RES	Renewable Energy Sources
RPS	Renewable Portfolio Standard
RUNRES	Rural Urban Nexus: Establishing a Nutrient Loop for Resilient City Region Food Systems
SACN	South African Cities Network
SADC	Southern African Development Community
SAGEN	South African Germany Energy Program
SALGA	South African Local Government Association

SAREM	South African Renewable Energy Masterplan
SAWEP	South African Wind Energy Project
SECAP	Sustainable Energy and Climate Action
SETAs	Sector Education and Training Authorities
SSEG	Small-scale Embedded Generation
TBL	Triple Bottom Line
TEA	Techno-Economic Assessment
TT	Transition Towns
TVET	Tertiary Vocational Educational Training
UCLGA	United Cities and Local Governments of Africa
VRB	Vanadium Redox Battery
VSC	Voltage Source Converter
WASA	Wind Atlas for South Africa
WCED	Western Cape Education Department
WWF	World Wide Fund for Nature

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1 GENERAL INTRODUCTION

1.1 Introduction

The industrial revolution brought about significant changes in today's society, transforming how people live, work, and relate to the environment (Sutcliffe & Bannister, 2020). One of the notable effects of this revolution is the increase in energy consumption, primarily based on fossil fuels such as oil and coal. However, the consequences of this consumption are now being felt as climate change and environmental degradation (Frost et al., 2014; Pata & Samour, 2022). Thus, climate change and environmental degradation have emerged as burning issues globally. As a result, efforts are being made to reduce the emissions of GHGs and carbon dioxide – which are key contributors to climate change – worldwide (Viardot, 2014). In doing this, several international conferences and conventions, such as the UN Framework Convention on Climate Change, the Kyoto Accord, and the Copenhagen Summit on Climate Change, have been organised to find lasting solutions to this problem (Fouché & Brent, 2019; Viardot, 2014). The global push towards finding alternative sources of energy that are more suitable, environmentally friendly and renewable, have led to the adoption of renewable energy (RE) to reduce harmful emissions (Martinez-Fernandez et al., 2013).

With recent climate change and environmental degradation developments, the need to adopt RE has increased. RE has gained considerable attention as a viable solution to reduce GHG emissions and mitigate the effects of climate change (Pata & Samour, 2022). RE sources, such as solar, wind, hydro, geothermal, and biomass, can provide clean and abundant energy without draining natural resources or damaging the environment. Hence, resources are being committed to exploring these options globally. However, promoting RE has gone beyond being the sole responsibility of the national government. Local governments also play a critical role in driving this agenda. This sphere of government directly influences urban planning, infrastructure development, land-use policies, and public services (Martinez-Fernandez et al., 2013). These statutory responsibilities significantly impact the adoption and integration of RE.

Although evidence suggests the involvement of the local government sector in RE, little is known about this role, especially regarding skill development (Devine-Wright, 2005; Martinez-Fernandez et al., 2013). Local government in the era of Industry 4.0 is a centre for developmental ideas. Local government is expected to go beyond traditional service delivery (Ramodula & Govender, 2021). The concept of developmental local government has been enhanced by the involvement of local government in global economic integration (Jili & Mthethwa, 2016; Ndebele & Lavhelani, 2017). This enhancement enables local governments to enact economic development policies that promote skill acquisition, socio-economic well-

being, environmental preservation, growth and prosperity of the people (Jili & Mthethwa, 2016; Ramodula & Govender, 2021; Zamisa & Mutereko, 2019). Therefore, local government plays a crucial role in promoting RE as a viable solution to the problem of global warming.

1.2 Problem Statement

According to economic empowerment and technological innovation theories, local governments are constitutionally empowered to promote the socio-economic development of their jurisdiction. For instance, section 152 of the Constitution of the Republic of South Africa of 1996 states the developmental responsibilities of the local government, especially in environmental and disaster management (Zamisa & Mutereko, 2019). Similarly, the White Paper on Local Government (1998) also emphasises the statutory role of local government in development processes (MashamaİTe & Lethoko, 2018). These documents position the local government through local economic development (LED) to tackle issues that bother services, sustainability, improving the quality of life of the people, poverty alleviation through skill development and provision of job opportunities, and preservation of human and natural resources (MashamaİTe & Lethoko, 2018). In this process, local governments in South Africa can partner with public and private stakeholders to achieve sustainable economic growth and development that enhance the quality of life and preserve resources (MashamaİTe & Lethoko, 2018).

As the sector closest to the people, local government plays a major role in adopting RE to mitigate climate change and environmental degradation. RE is a form of energy generated from natural resources such as sunlight, wind, and water. It is increasingly becoming an essential energy source globally and an alternative to fossil fuels. The local government sector's involvement is vital to creating an ecosystem conducive to adopting RE, mitigating climate change and environmental degradation, and benefiting skill development. A skilled workforce in the RE sector can be developed through the implementation of supportive policies, providing training programmes, offering funding support, collaborating with industry stakeholders, assisting in job placements, and promoting public awareness. Unfortunately, due to the political system in South Africa, local governments are limited in terms of resources and the human capacity to promote RE.

Data from previous studies on the role of the local government in RE has focused more on its moderating role rather than its involvement in promoting the agenda to bring about benefits for skill development. For instance, Zhao et al. (2021) examine the intervention of local government concerning feed-in tariffs in RE technological innovation. Similarly, Robinson and Stephens (2021)explore the role of local government in ensuring community engagement with RE companies. In another study, Sperling and Arler (2020) investigate innovation in the energy

sector and the participation of local government. Surprisingly, despite these studies, there is still a dearth of literature on the role of the local government sector in RE, especially on how it benefits the local community regarding skill development. This dearth of comprehensive scholarly works leaves local government practitioners, policymakers, and stakeholders in this sector without a basis for making evidence-based decisions because the understanding is based on speculation or conjecture. The consequence of this is that despite the crucial involvement of the local government sector in RE skill development, it lacks the capacity and the resources. Given this background, this study seeks to explore the role of the local government sector in promoting RE and its implication on skill development.

1.3 Research Objectives

This study seeks to explore the role of the local government sector in RE and its implication on skill development in South Africa by drawing from economic empowerment and technological innovation theories. The following objectives guide the study.

- To analyse the role of local government in adapting to renewable energy
- To determine if municipalities can be active in the field of RE production
- To assess the technical, economic and environmental feasibility of supporting households and economic entities with implementing RE systems.
- To identify skills required by the local government sector in promoting RE systems
- To explore international and regional best practices when implementing RE systems in the local government sector
- To identify potential challenges in the South African local government can face in promoting RE systems
- To make concise recommendations on strategies to empower local government to support the sustainable energy agenda

1.4 Research Questions

- What is the role of local government in adapting to RE?
- How can municipalities be active in the field of RE production?
- How can municipalities support households and economic entities with implementing renewable energy systems, considering technical, economic, and environmental feasibility?
- What skills are required by the local government sector to promote RE systems?
- What are the international and regional best practices on RE systems that can be implemented in the local government sector?

- What potential challenges can the South African local government face in promoting RE systems?
- What are the concise recommendations on strategies that can empower local government to support the sustainable energy agenda?

1.5 Methodology

This study aims to investigate the role of the local government sector in promoting RE and its impact on skill development. The qualitative component of this research involved conducting a systematic literature review using recommended protocols from the Joanna Briggs Institute (JBI), which included incorporating peer-reviewed articles, government documents, and other relevant literature sources. The review provides insight into how local governments adopt RE practices and their involvement in transitioning towards sustainable solutions. Additionally, the review examines how local governments support households and enterprises with implementing RE initiatives. Furthermore, it considers the specific skills required to successfully implement RE projects within the South African context by looking at regional and international best practices. Likewise, the challenges associated with transitioning to RE are reviewed, along with potential strategies or interventions that can address these obstacles effectively. Recommendations on strategies that can empower local government to support the sustainable energy agenda are provided.

The study utilised a Seven-Step Comprehensive Literature Review (CLR) approach. Firstly, the extensive literature on RE within the context of local government in South Africa was examined. Secondly, keywords pertinent to the subject matter were selected and employed for literature search from two academic databases. Thirdly, relevant literature was gathered systematically before conducting screening exercises to determine their suitability for inclusion or otherwise in the main analysis process. Fourthly, modes such as Media Observation(s), Documents Expert(s), and Secondary Data sources were added to expand the research scope during data collection mode processes or procedures composition respectively, thus constituting an improvement tactic upon previous studies' protocols structure designs that limited gathering information through only one means. Fifthly, critical analysis was applied to gather useful insights into the roles and involvement of the local government in the RE field. This analysis examined challenges associated with effective implementation and policy development, as well as shortages in skills and capacity, among other matters related to the promotion of RE local governments. Lastly, the communication, aimed at relaying findings via reports, conveyed specific recommendations for necessary actions required to realise the envisioned objectives and make meaningful contributions towards positive long-term effects and informed policy decisions.

Empirical research was conducted quantitatively using a Google Forms online structured questionnaire. The research questions were drafted from the findings of the literature review to fill in the identified research gaps. The survey targeted the private sector, local government officials, academics and experts in the RE sector. Stakeholder interviews were conducted using semi-structured questionnaires. A social network approach was used to identify some of the stakeholders and eligible participants.

Stakeholder interviews were conducted using semi-structured questionnaires. A social network approach was used to identify some of the stakeholders and eligible participants. Thematic analysis was used to evaluate the key informant interview qualitative data. This technique helped identify, analyse, and communicate data trends, creating detailed, varied narratives of participants' experiences. Thematic analysis identified the roles of local government in promoting renewable energy transition and adaptation, the feasibility of implementing renewable energy, international and regional best practices that can be adopted, skills requirements, potential challenges that can be faced and mitigation strategies. Online surveys, key informant interviews, and descriptive and thematic analytic methods provided a complete knowledge of local government leadership dynamics. This strategy ensured a diverse mix of experiences and viewpoints, improving our knowledge of how roles and participation of local governments can spearhead transition and adaptation to renewable energy. Participant data from uMsunduzi local municipality (R1), Trade and Investments KwaZulu-Natal (TIKZN) (R2), Council for Scientific and Industrial Research (CSIR) (R3), Nelson Mandela (R4), Bhesheni Energy Solutions (R5), Botswana University (R6) and Newcastle local municipality (R7) were painstakingly documented. These abbreviations simplified qualitative and quantitative data analysis. This coding approach simplified theme analysis and immediately tracked findings to municipalities and other respondents.

1.6 Outline

Section 1: General introduction

The section provides an overview of RE in South Africa and its global context, along with details on the social effects of climate change and environmental degradation. Furthermore, it emphasises how RE is considered a viable solution to reduce GHG emissions and mitigate the effect of climate change while pointing out the involvement of the local government sector in promoting renewable energy. The conclusion outlines research aims and objectives in addition to presenting the problem statement methodology while highlighting key points for this report’s structure.

Section 2: The role of local government in adapting to renewable energy

This section examines the factors that influence and guide the local government's incorporation of RE in South Africa while also explaining their role.

Section 3: Municipalities' role in the field of RE production

This section analyses and describes the contribution of municipalities in promoting RE. The factors that motivate their participation are explored, along with the obstacles to their involvement.

Section 4: The technical, economic, and environmental feasibility of supporting households and economic entities with implementing RE systems

This section explores and evaluates the possibility of promoting RE systems in households and businesses based on technical, economic, and environmental factors.

Section 5: Skills required by the local government sector for promoting RE systems

In this section, the necessary skills that are essential for transitioning into RE systems in the local government sector in South Africa are critically examined, and barriers and obstacles are highlighted.

Section 6: International and regional best practices for implementation

This section explores and outlines the current RE practices on an international and regional level. It also examines the successes, failures, strengths, and weaknesses that can offer valuable insights that South Africa could apply to its efforts.

Section 7: Potential challenges the South African local government can face when promoting RE systems

The section reviews the possible obstacles that local governments in South Africa might encounter while encouraging the employment of RE systems.

Section 8: General description and recommendations for best strategies and practices

All the findings on best strategies and practices for adapting RE by the local governments in South Africa are condensed, research gaps are described, and recommendations for policy change and implementation are provided.

2 THE ROLE OF LOCAL GOVERNMENT IN ADAPTING TO RENEWABLE ENERGY

2.1 Introduction

Extensive research has demonstrated how RE adoption is being utilised to address climate change's impacts (Rakowska & Ozimek, 2021; Tian et al., 2023). Recent climate change (global warming) developments, such as immense environmental pollution, damage, and high carbon emissions, have heightened the need to embrace RE as an intervention (DMRE et al., 2023). Countries are now incorporating alternative sources such as wind, solar, hydroelectric and geothermal power into their energy mix by shifting away from fossil fuels (Tian et al., 2023). Thus, the idea of having 100% clean energy is gaining popularity globally. A country like Uruguay has led by deploying a large-scale RE system to achieve almost 100% RE electricity. Similarly, Turkey has built a 100-km high-voltage transmitter to transmit solar power from high-energy areas to areas with deficient supplies (Tian et al., 2023).

South Africa ranks third globally in terms of its potential for solar energy, with an estimated 2500 hours (about three and a half months) of sunshine per year and receiving between 4.5 and 6.5 KWh/m2 daily (Fouché & Brent, 2019). Thus, the government has established explicit goals for RE integration within their overall plan, which includes reaching specific targets outlined within the Integrated Resource Plan (IRP), aiming towards adding at least 17,800 megawatts (MWs) capacity through renewables by 2030 (Fouché & Brent, 2019). The success achieved so far may be short-lived without adequate support from local governments who contribute significantly to job creation, economic growth, and decentralised systems that reduce transport distances and the costs associated with conventional resources (Fouché & Brent, 2019; Robinson & Stephens, 2021; Wlokas et al., 2017). However, policy effects are sensitive to RE source and policy instruments. Therefore, the review of the local government's role in the adaptation of RE is categorised under different factors, which are examined below.

2.2 Factors Guiding Local Government's Approach to RE Adaptation

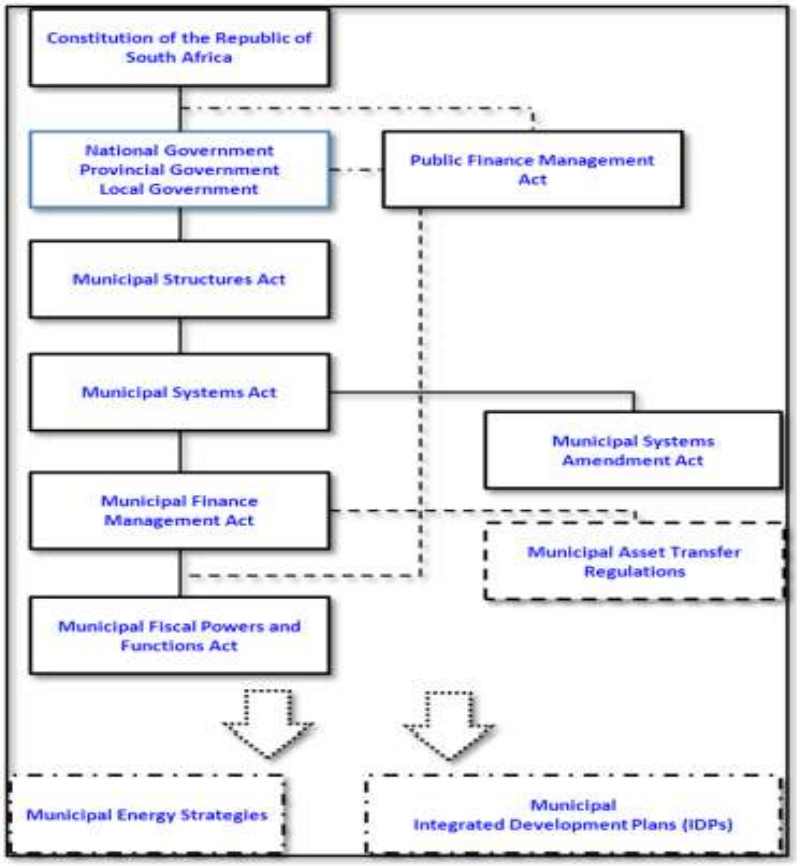
In the shift from a fossil fuel-based economy to a low-carbon one, local governments play an essential role as being the sphere of government closest to the people at the grassroots level (Gouchoe & Larsen, 2001; Tshehla, 2014b). More importantly, local governments have the authority to establish policies that integrate RE into their communities as set out by the constitution (Gouchoe & Larsen, 2001). Also, in the complex and interwoven nature of the energy systems, local government serves as an educator, regulator, financier and partner with private investors (Gouchoe & Larsen, 2001). Therefore, local government's adaptation and transformation process is guided by factors such as:

- Policy development and implementation
- Planning and infrastructural development
- Public outreach and education
- Partnership and collaboration

2.2.1 Policy development and implementation

In a recent study, Chai et al. (2023) assert that robust government policies are pivotal to the success of RE adaptation in decarbonisation efforts. In the context of South Africa, post-apartheid governance has introduced policy frameworks aimed at facilitating the implementation of RE implementation to promote the utilisation of natural resources towards ecological sustainability. White Papers released in 1998, 2003 and 2011, alongside the Integrated National Electrification Programme (2001), and the IRP (2011), outlined national goals and underscored the government's commitment to prioritising RE within its energy agenda (Fouché & Brent, 2019). Several previous studies have shown the need for and the benefits of decentralising energy sustainability (Borchers, 2015; Tian et al., 2023). According to Borchers (2015), centralising energy policy has the potential to revolutionise energy sustainability, given that local governments are the most intensive in terms of industrial concentrations, transportation usage, and household settlement. Therefore, sustaining the RE policy initiative at the local government level is crucial. Aligning local governments' strategic policies to drive the shift towards sustainable and clean energy through renewable sources is critical (Borchers, 2015). Figure 2.1 illustrates the local government's policy framework.

Figure 2.1: Local government's policy regulation representation



Source: Tshehla (2014b)

It is widely acknowledged that the role of the local government in eco-sustainability is paramount, thus making its involvement in setting energy transition policies inevitable (Mosdell, 2016). However, despite the importance of this role, there are instances where RE policies at the local government level lack consistency and coordination due to flawed design (Chai et al., 2023). Although Mosdell (2016) argues that local governments are not entirely free to change national policies, these policies are not restrictive but rather empower local governments to uphold, relax, or supplement the existing laws. For instance, section 151 (4) of the Constitution stipulates that the national or provincial government must not impede a municipality's power to exercise its control over its jurisdiction. Therefore, as policymakers, local governments must thoroughly understand the dynamics of RE generation before making informed choices at this level.

Mosdell (2016) further emphasises that the Constitution empowers local governments through the National Environmental Management Act (NEMA) and the National Environmental Management Air Quality Act (NEMAQA) to uphold policies and make stricter policies to protect the environment and ensure sustainable development. RE policies fall under these categories. It is also suggested that a well-developed RE policy at the local government level can attract private-sector participation and support other forms of advocacy. Furthermore, with the right

RE policy development and implementation, the interests of the communities are represented and protected as the policies will consider their socio-economic and environmental needs. However, Winkler et al. (2017) maintain that caution must be taken in RE policy development and implementation because they depend on the complex interaction of social, institutional, environmental, technical, and economic factors.

According to Yi et al. (2017), when favourable policies and regulations are established, RE projects see significant growth, which ensures seamless adoption and implementation of green technologies within the communities. Similarly, Kata et al. (2022) add that such policy initiatives streamline processes, eliminating common obstacles encountered during project development. Furthermore, establishing a specific RE policy encourages investments in innovative technology and stimulates the transition from fossil fuels to more environmentally friendly alternatives (Rakowska & Ozimek, 2021). Indications from these studies suggest that by planning and implementing the right and sustainable policies and regulations, significant rewards are achieved from RE initiatives.

Another notable point in policy development is the recent advancement in RE, which has led several national governments to act, resulting in many adopting climate policies. These policies are described as being motivated by benefits such as reducing air pollution, cutting costs, promoting community prosperity and providing economic development opportunities (Rakowska & Ozimek, 2021; Yi et al., 2017). However, Yi et al. (2017) point to certain factors that inhibit these policies, which include:

- Being foreign-oriented rather than localised: some policies fail to address local needs because they are not conceived based on local needs (Borchers, 2015).
- State mandates: Energy policies are mainly made at the national level and are only handed down to local governments. More importantly, local governments are not at liberty to change national policies. However, the policies are not restrictive; they empower local governments to add to them (Mosdell, 2016). The interference of the central government in policy development and implementation calls into question the autonomy of the local government.
- Co-benefits: Policy development and implementation are a statutory responsibility. Local government as a tier of government is also saddled with the responsibility of policy regulation as provided by the constitution (Fouché & Brent, 2019). Local governments must, therefore, transcend their traditional advisory roles in policy matters by actively identifying problems and proposing appropriate solutions (Borchers, 2015). Hence, there is a need for policies to originate from the local authority and to be localised.

- Political Interference: Political interference in policy development and implementation comes in different forms. For instance, it influences policy content, the implementation process, or the policy outcome (Tshehla, 2014b).

Another area where local government policy intervention is crucial is energy security (Tshehla, 2014b). According to Modsell, policy development and implementation must protect RE facilities, energy demand and supply, and energy environmental issues. Supporting this assertion, add that energy management policy, green building guidelines and policies, development zoning, easy access policy, and licensing are other RE areas that require policy planning and implementation.

2.2.2 Planning and infrastructure development

Transitioning to RE sources poses a unique challenge that requires comprehensive planning and coordinated actions (Gouchoe & Larsen, 2001). Adaptation of RE at the local government level could involve significant changes in infrastructure, policymaking, and awareness. Thus, local government planning must be guided through this complex transition process. According to (Fouché & Brent, 2019), RE planning depends on political will, technological feasibility, financial viability, and societal acceptance of the local government. Hence, the role of local government is critical in ensuring an interface between technological innovation, community and individual behavioural change, business orientation and practice, and institutional change. Fudge et al. (2016) call this a bottom-up approach.

The significance of a bottom-up approach in RE development is increasingly acknowledged by a growing body of literature (Fudge, Peters et al. 2016; Mey, Diesendorf et al. 2016). Local government RE planning and infrastructural development are important because they help mitigate climate change and RE as an alternative source (Mosdell 2016). According to Mey and Diesendorf et al. (2016), if they are well-planned, local government projects have the potential to expand RE infrastructure and institutionalise its adoption at grassroots levels. Also, engaging communities in RE planning processes and infrastructural developments motivates individuals to participate across various stages of project implementation, leading to increased efficiency gains for socio-economic growth.

Furthermore, Mosdell (2016) argues that local government must take cognisance of the energy needs of the community as part of its integrated development planning and service delivery. Meanwhile, countries like Denmark, Germany and the UK offer successful models having adopted such an approach (Kata et al., 2022; Mey et al., 2016). However, Mey et al. (2016) emphasise that regardless of the approach, the main barrier to local government's RE planning and infrastructural development is the high cost of investment, which is usually

beyond the local government's budgetary capacity. This barrier accounts for the low RE adoption and support rate at the local government level (Rakowska & Ozimek, 2021). In addition, Fouché and Brent (2019) state that care must be taken in RE infrastructural planning and development as it must be determined that it fits into the local government's RE strategy.

In line with this, Kata et al. (2022) further submit that a well-structured and long-term RE policy must be in place for effective planning. In doing this, collaboration between all stakeholders is required. Hence, the needs of the stakeholders must be considered. Based on the Sustainable Energy and Climate Action Plan (SECAP), initiated by a Covenant of Mayors in Poland Kata et al. (2022) argue that a sustainable action plan should include an analysis of the current energy situation and GHG emissions in a city. For example, SECAP was designed to establish specific renewable energy targets, improve energy efficiency, and decrease carbon emissions. In addition, the plan provided an opportunity for effective communication between the local government and the communities. Surprisingly, over 10,000 local and regional governments in over 54 countries have adopted this Action Plan (Mey et al., 2016). In essence, a coordinated action plan is essential for the local government's adaptation of RE.

2.2.3 Public outreach and education

Statutorily, local governments are responsible for educating the public on policy matters (Azevedo et al., 2013; Mosdell, 2016). Azevedo et al. (2013) posit that local governments possess the necessary skills and resources to promote RE sources by emphasising the environmental benefits, financial advantages, and long-term cost-savings of clean energy solutions. This approach is called 'tambourines'. It is a soft mechanism where public awareness campaigns are conducted through various activities such as workshops, community outreach programs or information drives aimed at inspiring stakeholders towards adopting sustainable practices while offering policies that promote this change (Azevedo et al., 2013).

Local governments have a crucial role in adopting RE to reduce GHG emissions, promote economic development, and ensure long-term energy security by creating awareness. These efforts significantly mitigate climate change impacts and create a sustainable future for future generations. Given this significance, it is imperative that local authorities consistently prioritise initiatives related to RE and actively pursue achieving their objectives. In line with this, Fudge, (Anderson & Peters, 2016) argue that there is a need for a shift in citizens' beliefs, values, ideas, and orientations on the benefits of RE in the community. This shift will only come about through education and awareness campaigns.

Furthermore, Gouchoe and Larsen (2001) explain that one of the major elements of local government involvement in RE initiatives is an awareness campaign and outreach. The authors cite the engagement of over 100 local governments in RE public outreaches and awareness in the United States of America. These local governments were involved in media campaigns designed to spread the benefits of RE among the community. Also, the local governments sponsored RE technical training, activities in schools, workshops for professionals and contractors, and consumer-oriented seminars. Additionally, local government can support RE projects designed for public awareness.

2.2.4 Partnership and collaboration

Financial assistance or incentives for RE projects are within the powers of local governments (Gouchoe & Larsen, 2001). This support can take various forms, such as grants, subsidies, and low-interest loans targeting individuals, businesses and organisations interested in solar panels or wind turbine technologies. According to Gouchoe and Larsen (2001), these incentives alleviate installation costs, making it more feasible to invest in green energies. The tax incentive is another initiative that can be deployed to encourage RE partnership or collaboration. For instance, in the United States (US), 15 states exempt certain RE devices from taxes. This dispensation was also adopted by many local governments in the US (Gouchoe & Larsen, 2001).

Thus, local authorities need to go beyond policy-making and financial backing by assuming intermediary roles that promote collaboration between stakeholders involved with renewable initiatives like investors, developers, utility firms, research institutions, and community groups fostering partnerships tailored towards specific regional needs. Such activities encourage synergies, accelerating the uptake of efficient residential electricity generating systems while promoting environmental conservation measures through sustainable practices. Local governments facilitate collaboration between various stakeholders involved in renewable initiatives by acting as intermediaries (Gouchoe and Larsen 2001).

2.3 Summary

The role of local government in adapting to RE is crucial for achieving a sustainable and clean energy future. Local governments have the power to set policies and establish regulations that promote the use of RE sources. Also, providing incentives and financial assistance can encourage individuals, businesses, and industries to adopt RE solutions. Additionally, local governments can lead by example by implementing RE projects in their facilities. Collaboration with stakeholders such as utility companies, communities, organisations, and residents is essential for developing effective strategies and programs.

3 MUNICIPALITIES' ROLE IN THE FIELD OF RENEWABLE ENERGY PRODUCTION

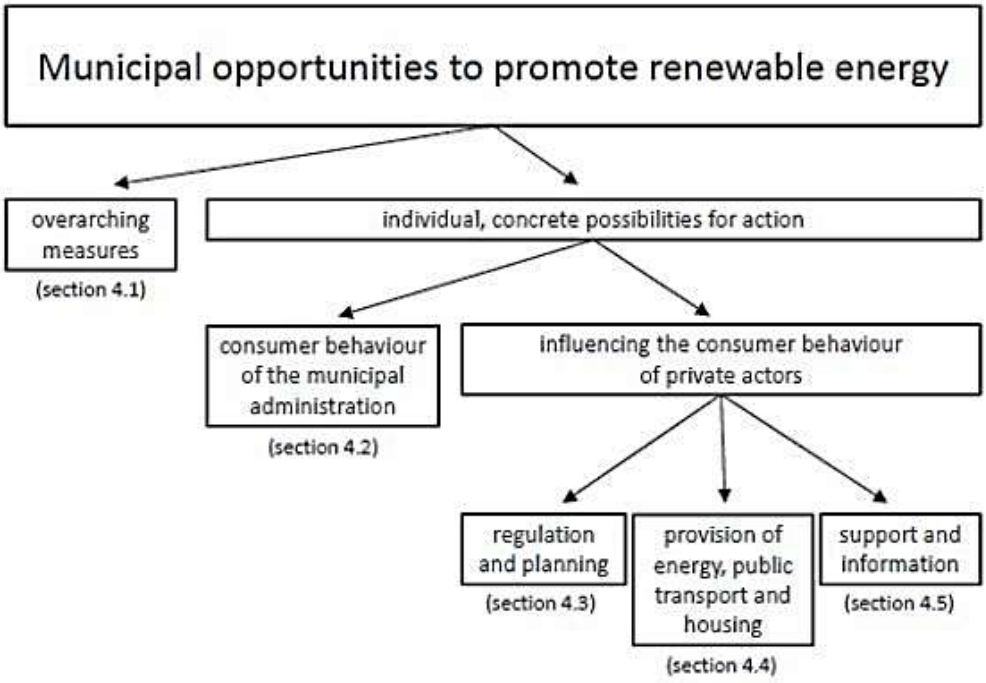
3.1 Introduction

Local municipalities are classified under Category B in the classification of municipalities in South Africa (Agyepong & Nhamo, 2015). As empowered by the Constitution of the Republic of South Africa and the White Paper on Local Government of 1998, local municipalities play an essential role in local economic and environmental development under which RE is categorised (MashamaİTe & Lethoko, 2018; Mngoma et al., 2011). Local municipalities are responsible for creating and implementing policies, regulations, and incentives that encourage the use of RE technologies within their jurisdictions. These measures range from feed-in tariffs to tax credits, grants, and sustainable building codes. Similarly, local municipalities often collaborate with regional and national authorities to develop comprehensive strategies for adopting RE.

Numerous studies have highlighted the important role of municipalities in the RE field (Brandoni & Polonara, 2012; Fouché & Brent, 2019; Schönberger, 2013; Tshehla, 2014a). Brandoni and Polonara (2012) investigated the role of municipalities in energy-saving planning by analysing the energy plans of 12 Italian municipalities, which operate as energy regulators in the region. The results showed reduced carbon emissions and a significant contribution to the region's RE target. While this study presented the achievements of the municipalities, these achievements were based on the regional master plan. Therefore, municipalities must endeavour to develop their independent renewable energy plans.

Also, while analysing opportunities, obstacles, and multi-level influence in the RE field, Schönberger (2013) examined German municipalities as key players in RE governance. The study, which was a comparative analysis of state, municipality, and private sectors in RE governance, reveals that although both the private sector and the state have gained popularity in the last two decades, the municipality's role has become crucial as they apply five distinct and important modes of RE governance which include overarching measures, consumer behaviour of the municipal administration, regulation and planning, provision of energy public transport and housing, and support and information (Schönberger, 2013). Figure 3.1 presents municipality RE modes.

Figure 3.1: Municipality RE modes



Source: (Schönberger, 2013)

The author describes overarching measures as a distinctive approach that encompasses the municipality's target share of RE, reduction of GHG emissions, climate action plans, collaborative efforts, and initiatives for renewable energy and climate protection within the jurisdiction. On the one hand, consumer behaviour of the municipal administration involves adopting strategies to reduce energy usage to meet renewable energy (RE) needs. On the other hand, regulation and planning are measures implemented to ensure climate protection and promote RE utilisation. Additionally, municipalities, as key players in the RE field, promote and facilitate the adoption of energy-saving systems such as electric mass transit buses and buildings equipped with energy-saving devices. In terms of support and information provision, municipalities implement policy measures in the absence of specific regulatory policies. These measures include energy consulting services, educational support strategies, financial incentive programs, and initiatives to attract RE investment (Schönberger, 2013).

In another study, Andersson et al. (2019) examined municipalities' role in the RE field by considering several collaborative activities that increase the sustainability of RE initiatives. These include networking, RE projects, consulting, and information dissemination. The result of the study revealed a significant impact on fossil fuel consumption, especially in the transport sector. Another benefit highlighted by the study is the awareness of many RE opportunities. The research indicates a clear correlation between proactive local governance and higher percentages of installed capacity generated from renewables compared to areas lacking strong governmental support. In addition, by cultivating a sense of ownership among

communities, municipalities encourage individuals to adopt renewable technologies at home and within their businesses. The dedication of these municipalities is evident through incorporating sustainable practices into their operations. Many municipalities are already implementing eco-friendly measures. Doing so decreases their environmental impact and is an influential example for citizens and companies.

Moreover, as the municipality's active involvement in renewable energy (RE) gains momentum, there are indications that this motivation stems from various factors. Fraser (2021) categorises these motivations as technical resources, economic conditions, social resources, and country-level factors, including policy tools, geography, and development status.

3.2 A Municipality's RE Motivations

Municipalities play a crucial role in the field of RE production. However, this role is predicated on several conditions reviewed below.

Technical resources: Technical resources refer to abundant natural resources such as solar, large land mass, and population density that can attract RE industries and support the development of RE plants. Municipalities with ample technical resources are more likely to venture into the RE field. For instance, a municipality with a large land mass and population can host RE plants with high electricity demand (Fraser, 2021).

Economic conditions: Economic conditions play a significant role in a municipality's embracing of RE initiatives. This factor has been identified as a major contributor to municipalities embracing RE initiatives. For instance, financially struggling municipalities may see the physical benefits and financial income from hosting RE plants as a motivating factor. Conversely, financially stable municipalities may consider additional economic benefits like employment and community development (Fraser, 2021).

Social resources: Like economic conditions, social resources also determine the municipality's role in the RE initiatives and the field. Social resources refer to social ties that bring collectivity and collaboration to a community. These include social bonding, social bridging, and social capital. Social ties explain the intra-relationship that connects people in a community, like ethnicity. Social bridging, on the other hand, is a broader bond among the people. These are the inter-group ties within the community or municipality, fostering civic engagement. Social capital explains the vertical ties between the community and its elected or appointed officials. These social resources determine the level of the municipality's role and involvement in the RE initiative (Fraser, 2021).

Country-level factors: There are factors peculiar to countries that determine their involvement in RE projects and initiatives, which include policy tools, geography, and development status.

I. *Policy tools:* This factor encompasses the policy decisions made regarding RE initiatives. Policy tools indicate the design of policies to either embrace or refrain from RE projects. These tools are crucial as they guide the municipality's policy development on energy, education, disaster management, and other relevant areas.

II. *Geographical diversity:* This refers to the topography, physical characteristics, human elements, and cultural features of the land. These diverse features play a significant role in determining how municipalities engage in RE initiatives.

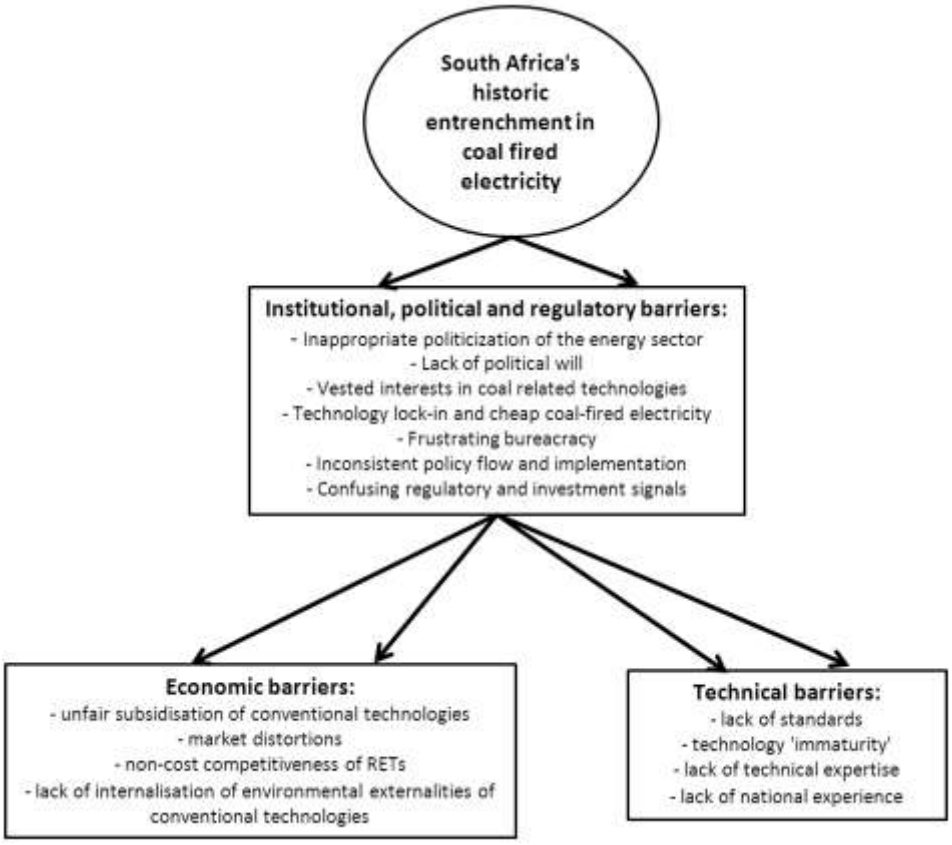
III. *Development status:* Developmental status plays a significant role in determining the involvement of a municipality in renewable energy (RE) initiatives or projects. Fraser (2021) suggests that a less integrated economy will experience different levels of attention or attraction towards RE compared to an economy with free trade and bilateral relations.

Municipal involvement in RE is viewed as contributing to energy democracy by promoting access to clean energy and alleviating energy poverty. However, despite their regulatory power, municipalities face barriers to achieving their goals in promoting RE projects. (Fraser, 2021).

3.3 Barriers to the Municipality's Role in the Field of RE

Barriers, also known as roadblocks in energy transition, are hindrances or obstacles to achieving a target or objective (Todd & McCauley, 2021b). Studies in the field of RE have identified several barriers hindering the municipality's role in the field of RE in South Africa (Özgül et al., 2020; Philibert, 2017; Tshehla, 2014a). Tshehla (2014a) categorised these barriers as economic, regulatory, technological, and social barriers. Coincidentally, the factors that motivate their involvement can also stand as barriers to their involvement. Figure 3.2 presents the hierarchy of barriers to RE in South Africa.

Figure 3.2: Hierarchy of barriers to RE in South Africa



Source: (Tshehla, 2014a, p. 38)

Economic Barriers: According to Tshehla (2014a), South Africa's long dependence on coal-generated energy makes RE look far less cost-competitive. Thus, this stands as an economic barrier to RE initiatives (Philibert, 2017). Also, it has caused the RE project to be politicised, resulting in policy barriers. Other economic barriers include the following:

- ***High financial costs***: High initial investment costs pose a significant challenge to municipalities seeking to participate in the field of RE. Often, implementing RE projects requires substantial upfront capital, which may be difficult for municipalities to obtain (Todd & McCauley, 2021b). This barrier is particularly challenging as it may deter municipalities from pursuing RE initiatives despite the potential long-term benefits.
- ***Financial Funding:*** Municipalities struggle to secure the necessary funding opportunities to support RE projects. Limited financial resources further compound this issue, as municipalities may lack the necessary funds to invest in RE infrastructure and technologies (Özgül et al., 2020). Overall, high initial investment costs are a

significant economic barrier that municipalities must overcome to participate actively in the RE projects.

Regulatory Barriers: Regulatory barriers present significant challenges to municipalities seeking to play a role in the field of RE. Complex permitting processes create delays and bureaucratic hurdles that hinder the implementation of RE projects. Inconsistent government policies further increase these obstacles as municipalities struggle to navigate a constantly changing landscape (Özgül et al., 2020). According to these authors, the lack of supportive legislation means that municipalities often face uncertainty and ambiguity when it comes to RE initiatives. These regulatory barriers not only impede the progress of individual projects but also contribute overall to hindrances in transitioning to a clean energy future. Without effective and streamlined regulations, municipalities will continue to face difficulties in fulfilling their potential as leaders in RE adoption (Tshehla, 2014a).

Technological Barriers: Technological barriers arise from limited access to advanced RE technologies, which hinders the adoption and implementation of RE on a large scale (Tshehla, 2014a). In addition, Tshela argues that municipalities often lack the necessary technical expertise and knowledge to utilise and maintain RE systems effectively. Also, the absence of technological standards for integrating new technologies with existing infrastructure impedes the progress of municipalities in transitioning towards RE sources. It hinders their ability to contribute to the development of a sustainable energy future (Özgül et al., 2020).

Social Barriers: One of the major social obstacles faced by municipalities in their pursuit of RE initiatives is the lack of public awareness and support. Many individuals are still unfamiliar with the benefits of RE sources and are sceptical about their feasibility (Özgül et al., 2020). This lack of awareness often leads to general disinterest and apathy towards RE projects, making it difficult for municipalities to garner the necessary support and resources. Also, municipalities face opposition from local communities when implementing RE projects. This opposition can stem from various factors, including concerns about the visual impact of RE infrastructure, a potential decrease in property values, and fear of associated noise or other environmental impacts. This resistance from the local community creates significant hurdles for municipalities, as it may result in delays, legal battles, or even abandonment of the projects altogether. The perception of RE sources as unreliable or inefficient is another social barrier to the municipality's involvement. Some individuals still hold the belief that RE technologies, such as solar or wind power, are not dependable or capable of generating sufficient energy to meet the needs of the community. This perception can hinder the adoption of RE projects by municipalities and reinforce the status quo of reliance on traditional energy sources (Özgül et al., 2020).

For municipalities to overcome these social barriers, it is crucial to focus on raising public awareness about the benefits and feasibility of renewable energy. It can be done through educational campaigns, community engagement initiatives, and the active involvement of local stakeholders. By addressing concerns, debunking myths, and showcasing successful examples of RE projects, municipalities can build trust and gather support from their communities, ultimately enabling them to play a more effective role in the field of RE.

3.4 Summary

The municipality's role in the field of RE production was highlighted in this section as findings from scholarly reviews revealed motivators for this role. The review further showed the resources that encourage the municipality's involvement while the barriers were also identified and examined.

The objective of this section was to examine the municipality's role in the field of RE production. While doing this, several scholarly works were reviewed for in-depth analysis. Findings revealed several municipalities' roles in the RE field. However, these roles depend on several factors. For instance, municipalities involved in RE initiatives and implementation are based on the resources at their disposal. These include economic, technical, social, and country-level-factor resources. These factors are essential as they determine the level of the municipality's involvement in RE projects. Unfortunately, the study also revealed certain factors that are obstacles to municipalities' active role in the RE field. These are policy, economic, technological, and social barriers.

4 THE TECHNICAL, ECONOMIC, AND ENVIRONMENTAL FEASIBILITY OF SUPPORTING HOUSEHOLDS AND ECONOMIC ENTITIES IN IMPLEMENTING RENEWABLE ENERGY SYSTEMS

4.1 Introduction

Several socio-economic challenges, including energy, burden South Africa. The country has been facing serious power shortages, affecting several crucial economic sectors as well as the health sector, which needs a continuous energy supply. Local municipalities, in their legal obligations under the Municipal Systems Act (2000), have assigned a department to foresee and run sustainable energy provision. Thus, RE may be implemented in parallel with conventional main grid sources (eThekwini municipality, 2020). Transitioning towards a green energy economy is a complex process that needs careful consideration in selecting the best technologies that are economically viable, socially acceptable, and legal (Hirwa et al., 2023). In addition, the implementation and successful scaling up of such technologies depends on the existence of an enabling policy environment. This section probes into these issues by describing current challenges and provides recommendations for each actor in the service value chain.

4.2 Literature review

4.2.1 Technical feasibility

There are several technologies to support the RE transition in pursuit of decarbonising the energy sector. These technologies include green hydrogen, wind energy, hydro, biomass, solar, wind and Concentrating Solar-thermal Power (CSP) (Akinyele & Rayudu, 2016; Ali et al., 2023; Aliyu et al., 2018).

Techno-economic assessment (TEA) is a method that analyses the economic performance of an industrial or organisational service using mathematical models. The TEA provides decision-making for authorities considering the implementation of viable business models. The tool uses input parameters such as capital and expenditure costs, revenue generation and other financial parameters (Manfren et al., 2021). Naicker and Thopil (2019) list major technical feasibility parameters such as local availability of materials, technological maturity, ease of transfer of skills, and ease of maintenance.

4.2.2 Resource assessment

4.2.2.1 Wind energy

Wind energy has been proven to be the most viable option in South Africa due to massive winds in the coastal areas. Wind energy is generated when the wind flows past through the blades of the turbines (eThekwini municipality, 2020). Coastal areas are the best areas to locate wind energy because of high onshore winds. The South African Department of Energy mapped and characterised areas with high wind potential and generated maps (Diab's Wind Atlas) that can be used by local municipalities for decision-making (Akinbami et al., 2021). Based on Diab's wind Atlas, the Western, Northern and Eastern Cape have the highest wind potential. In contrast, KwaZulu-Natal and areas of the Drakensberg have medium potential, and the least is the North West province, which is more inland (Akinbami et al., 2021). Currently, a comprehensive Wind Atlas for South Africa (WASA) has been developed by the South African Wind Energy Project (SAWEP) to guide entities in choosing the best site for a wind farm. A study by the Council for Scientific and Industrial Research (CSIR) showed that 80% of South African land mass has sufficient winds to satisfy a load factor of >30% (Sustainable Energy Africa, 2017), confirmed to be far larger than Germany's potential (eThekwini municipality, 2020). A feasibility study done in eThekwini metropolitan municipality in 2011 identified ten sites where 86 turbines can be installed to generate 215MW of electricity at a windspeed of between 6 and 7.3m/s and a height of 100m (eThekwini municipality, 2020). However, to date, about 27 wind farms have been launched in the Eastern and Western Cape between 2008 and 2017.

Despite variations in wind speeds across the country, smaller turbines can be considered for household generation. For example, a feasibility study done in Maluti-A-Phofung municipality showed that even when the wind direction and speeds are not ideal for large-scale generation, they can be downscaled to the household level (Mapuru et al., 2022). Cases have been reported in which households are producing electricity using small-scale wind generators in the Westville and Sherwood areas of Durban (Sustainable Energy Africa, 2017).

Wind energy generators are one of the most mature technologies that can be used with minimal difficulties. Based on a TEA done by Naicker and Thopil (2019), wind energy ranked the best (4 out of 4) in terms of technological maturity, availability of local champions, ease of skill transfer (3.5 out of 4) and ease of maintenance (3.2 out of 4). The ease of maintenance score is a smaller value due to certain technical issues. For example, wind farms should be located away from residential areas, rendering the distribution of electricity expensive and creating other technical challenges such as voltage fluctuation (Akinbami et al., 2021).

Despite these technical issues in maintaining wind energy, Naicker and Thopil (2019) argue that South Africa is technically equipped to operate wind farms without problems.

Wind farm establishment costs are very low. Doorga et al. (2022) report that the levelised costs of constructing wind farms in South Africa are 16.7% lower than those of constructing coal-powered electrical stations. The levelised cost of constructing solar farms in appropriate areas of Egypt is 29.7% lower than the establishment of combined gas turbines and 37% lower than diesel generators.

In conclusion, wind energy is one of the most mature RE technologies that can provide commercial-scale energy in areas with >6m/s wind at 100m. In areas where wind is lower, wind technology can provide household electricity. The establishment costs for wind energy are generally lower than for conventional coal-based energies.

4.2.2.2 Solar energy

Solar energy emerges as a highly reliable and feasible renewable energy technology for widespread adoption in South Africa, owing to its ample annual radiation intake. A solar photovoltaic system (PV) is defined as an electrical system that converts solar energy into electricity. Northern Cape has the highest DNI (Daily Natural Irradiance) in South Africa reaching as much as 3200 kWh/m^2 which is very low in KwaZulu-Natal (1400 kWh/m^2) (Akinbami et al., 2021). A solar PV yield, just like wind energy, is affected by meteorological conditions such as solar radiation, aspect and seasonal variations. South Africa has one of the best conditions for solar PV because it receives 8-10 hours of sunshine which translates to a national average of 2 500 hours per year and 4.5-6.6 kWh/m^2 of radiation level (Jain & Jain, 2017). Currently, South Africa has 21 solar PVs producing approximately 1 300MW of power: Northern Cape (13), North West (3), Free State (2) and Eastern Cape (3) (Akinbami et al., 2021). However, there are fewer CSP projects (five parabolic troughs and one power tower) in South Africa, which all generate 500MW for the national grid.

Municipalities have the chance to invest in renewable energy (RE) across various scales, including households and commercial enterprises. A TEA of solar PV energy at the household level in Durban, South Africa, demonstrated its technical viability (Ebhota & Tabakov, 2021). Solar energy is one of the solutions to the prevailing energy insecurity at the household level in South Africa. For example, the use of solar energy for heating water was estimated to reduce total energy consumption from the main grid by 18% (DMRE, 2004). This reduction can save a lot of energy from existing power blackouts, considering that household consumption constitutes 23% of the total energy consumption per sector (Bohlmann & Inglesi-Lotz, 2018).

4.2.2.3 Biomass energy

There is also an opportunity to tap into biomass energy, considering the vast organic waste streams available from South African landfills, agricultural waste, livestock products, and paper companies. Biomass energy is the form of RE obtained directly or indirectly from organic matter in a liquid, gaseous or solid form (Akinbami et al., 2021). There are global energy opportunities for biomass energy; for example, China and Greece have the potential to cover between 99% and 135% of their energy needs from livestock and agricultural residues only, respectively (Aravani et al., 2022). However, some other municipalities, such as eThekwini municipality (2020), have been considering harnessing biomass energy for household consumption. Waste streams done in 2007 show that the municipality can produce approximately 1.5GW of power from available organic material. However, the general contribution of biomass to the overall energy demand for KwaZulu Natal is 0.06% (Mutombo & Numbi, 2019). Biomass energy is shown to be the least mature technology when compared to solar PV and wind energy. According to an assessment by Naicker and Thopil (2019), biomass energy had the lowest Digital Maturity Model (DMM) scores in terms of technology maturity, availability of local actors and ease of skills transfer. Mbazima et al. (2022) consider biogas energy as cheap and clean energy. However, its use is currently not taken seriously in South Africa. Six out of the 17 planned projects have been successfully implemented. They are generating approximately 15MW for the local grids of KwaZulu Natal, Gauteng, and Western Cape provinces. Mbazima et al. single out the reliance on coal, which is in abundance in South Africa, as the major barrier to prioritising landfill gas energy. Some other techno-economic issues were a lack of municipal, institutional capacity to operate and maintain such projects, skills shortage and inadequate research on waste stream quality and quantity. Otherwise, more research and development centered on biomass energy production is crucial.

4.2.3 Infrastructure

4.2.3.1 Grid integration

South Africa is fighting two intertwining challenges: energy security and climate change mitigation. The South African IRP has emphasised the need to mix energy sources from renewables and bring them to the national grid to meet local demands and promote economic development (DMRE, 2019). Considering the large potential for solar PV and wind energy in South Africa, it is imperative to understand the capacity of existing infrastructure to accommodate extra energy. There are existing challenges with integrating Independent Power Producers (IPPs) onto the national grid. One of them is the lack of adequate information on the technical risks and mitigation strategies to include RE in the national grid (DMRE, 2019). Another challenge is the nationwide South African grid maintenance backlog, especially in the Cape Province, where wind and solar energy generation potential is high (DMRE et al., 2023).

Eskom, the state-owned transmission and distribution company, does not even have the financial capacity to maintain its infrastructure (Eskom, 2019). Despite financial constraints, the South African Renewable Energy Masterplan (SAREM) proposed that Eskom develop an implementation plan for infrastructure that will consider transmission and distribution networks, clear grid access rules, and best RE deployment (DMRE et al., 2023).

Government policy enhancements create opportunities for increased electricity integration into municipal grids. These revisions allow IPPs, including Small-scale Embedded Generation (SSEG), to supply energy to municipalities and the national grid without the previous bureaucratic hurdles of the National Electricity Regulator of South Africa (NERSA) registration (DMRE et al., 2023). Addressing infrastructure constraints could unlock the potential for all IPPs to contribute to the national grid, contingent upon enhanced energy market capabilities.

4.2.3.2 Energy storage

Power generation from RE is dynamic; for example, solar and wind generation depends on prevailing climatic conditions. Firstly, if the energy is not captured and stored, it will be lost. Secondly, South Africa needs extra energy during high-demand periods, which can lead to load shedding, so battery storage may help alleviate the situation (Mirzania et al., 2023). There is a range of batteries that can be used for energy storage, which include Lead-acid, Lithium-ion, Sodium Sulphur, Nickel Chloride, Zinc Bromide and Vanadium Redox Batteries (VRB) (Thango & Bokoro, 2022). Lithium-ion batteries are the most viable for large-scale energy storage based on economic and technical parameters assessed by Thango and Bokoro (2022). Some technologies, such as VRB, are still to be tested at a utility scale, and they may need further research before being considered.

The South African economic landscape presents significant opportunities for growth in the LED batteries manufacturing sector and green energy storage solutions. As reported by DMREDSI and DTICC (2023), the adoption of E-mobility applications has led to a substantial surge in energy storage technology deployment, increasing from 0.5 gigawatt-hour (GWh) in 2010 to 997 GWh in 2021. This trend extends to the Vanadium Redox Flow Battery market, which is projected to reach an annual installed capacity of up to 30 GWh by 2030. Additionally, the University of Western Cape's hydrogen initiative is currently exploring practical applications of the hydrogen economy within the South African context (DMRE, 2019).

Technical challenges associated with lithium-ion batteries have been highlighted in a review by Thango and Bokoro (2022). These challenges encompass output power smoothing, load cutting off, frequency regulation, plant dispatchability, and energy arbitration. The authors propose that these issues can be addressed through the implementation of specifically

designed algorithms, underscoring the need for advanced technical skills to operate such systems effectively.

4.2.4 Economic feasibility

Municipalities are inclined to invest in sustainable and economically viable technologies. Numerous studies have examined the economic viability of RE technologies throughout the entire service chain in contrast to conventional energy sources. Rediske et al. (2021) outlined economic feasibility parameters crucial in site selection for RE, including land costs, total investments, construction expenses, operation and maintenance costs, and government support. Additionally, Mbazima et al. (2022) evaluated economic feasibility based on electricity generation sales and certified emission reductions.

Most RE technologies are economically feasible in terms of returns on investments. The Levelised Cost of Electricity (LCOE) is a constant value that shows the total construction costs and operations of an electricity-generating unit over its lifespan (Naicker & Thopil, 2019). The LCOE of various RE technologies is lower for wind and solar energy compared to coal power (Doorga et al., 2022). Transmission costs and voltage variations may reduce reliability and power yields from wind farms (Akinbami et al., 2021). In this regard, a voltaic source converter can be used for overhead and cable transmission (Acaroğlu & García Márquez, 2023). The availability and low cost of materials to optimise electricity generation and transmission from wind farms provide an opportunity for low-cost production in South Africa (DMRE et al., 2023). The same applies to the local availability of spare parts for RE technologies. A techno-economic analysis of solar PV equipment manufacturing done in Steve Tshwete municipality shows that the material can be made at a lower cost in South Africa than imported (Semelane et al., 2021). The authors suggest that this is more economically viable if governmental incentives are injected. The same applies to the High Voltage Direct Current (HVDC) for long-distance energy wheeling from wind farms in Turkey, in which its costs could not break even if there were no government subsidies (Acaroğlu & García Márquez, 2023). A study was done to assess economic viability and technical concerns arising from third-party transportation of energy between an Independent Power Producer (IPP) and an industrial consumer in South Africa (Murray, 2018). The LCOE and Net Present Cost (NPC) analysis showed wind energy generation is very economically viable and grid parity can be reached faster with larger wind systems. Wheeling costs were presumed to be very high, but the authors suggest that the costs can be offset by tariffs. However, deregulation of the electricity markets is required to open competitive markets. The recent draft of SAREM shows that the government is fasttracking the growth of all markets segments as part of the unbundling of Eskom (DMRE et al., 2023).

The recognition of RE in industrial development is prominent in South Africa, as evidenced by the scrutiny of existing policies that hinder the implementation process. For example, the SAREM seeks to align industrial policies and programs with RE and storage locations. One of its interventions is to reactivate the 12i tax allowance incentive to support RE and battery manufacturing value chains (DMRE et al., 2023). This intervention provides an opportunity for manufacturing companies to access incentives for smooth RE material availability.

Depending on the scale, RE sources such as solar PV can save energy costs for various entities ranging from small-scale energy at the household level (Kassem et al., 2023), rural microgrids (Akinyele & Rayudu, 2016) and even large national and international grids (Acaroğlu & García Márquez, 2023). With efficient energy integration on a smart grid, the municipalities have the potential to generate energy at economies of scale. A life cycle analysis done in Turkey by Acaroğlu and García Márquez (2023) showed that HVDC overhead transmission lines could reach a breakeven point 15 years earlier than the Voltage Source Converter (VSC) and the Line Commuted Converter (LCC) technologies.

South Africa has opportunities for ethanol production from vast sugarcane and forestry biomass in KwaZulu-Natal (eThekwini municipality, 2020) and municipal solid waste (Godfrey et al., 2020). These sources can be tapped for energy production at an economic scale. For example, an economic feasibility study for biogas production on a small island system showed to have a payback time of 4 – 5 years due to savings in maritime transport and avoiding waste disposal on land. Currently, municipalities do not have enough financial resources to invest in RE technologies that can operate profitably (SALGA, 2021). Municipal financial capacity may not be a barrier to economically viable energy generation if co-financing sources from private investors are considered. This option is viable if private-public partnerships are prioritised to operate energy production at scale (DMRE, 2004; Mungodla et al., 2018; Nel, 2015).

4.2.5 Environmental feasibility

Global action on climate change mitigation is the major driver for the consideration of RE as part of the 2015 Paris Agreement (Mungodla et al., 2018; Mutombo & Numbi, 2019; Todd & McCauley, 2021a). South Africa has the largest reserves of coal in Africa, contributing magnificently to GHG emissions (Todd & McCauley, 2021a). The use of RE sources such as solar and wind provides clean energy without any emissions (Kassem et al., 2023). A study by Heidari and Heravi (2023) showed that the use of solar PV in Iran will prevent 101 million tons of carbon dioxide emissions in 20 years. Life cycle analysis of solar PV in a small community in Nigeria showed that a solar PV microgrid (SPM) has an emission rate of 56.7 gCO2-eq/kWh, which equates to between 8.15% and 9.84% of the emission rates of the diesel system.

The implication of RE on the environment concerning wildlife and aesthetics is of utmost importance. Despite perceived environmental benefits, the implementation of RE has several environmental implications concerning land and resources, esthetics and pollution (noise pollution) (Acaroğlu & García Márquez, 2023; Yaqoot et al., 2016). South Africa has vast land to support RE without any problems with the natural habitat. For example, 37% of the South African landmass is ideal for solar farms, while 57% is ideal for wind farms (Gaeatlholwe & Langerman, 2023). However, this is not the case in all municipalities. Some municipalities, such as eThekwini, do not have adequate sites to install wind turbines due to scattered settlements (eThekwini municipality, 2020). The operation of wind turbines generates noise that is not pleasant to residents nearby and may chase animals away from their natural habitat (Akinbami et al., 2021). Large-scale wind turbines create areas of low pressure, which is fatal to birds when they fly closer, leading to high fatalities (Akinbami et al., 2021; Rediske et al., 2021). Over 250 bird fatalities were reported for the first set of wind turbines installed under the Renewable Energy Independent Power Procurer Procurement Program (REIPPPP) program in South Africa (Akinbami et al., 2021). Mitigation strategies in that regard include proper planning and avoidance of such areas (Rediske et al., 2021). The Environmental Impact Assessment (EIA) is mandatory for large-scale installation of wind and solar farms, as per the South African NEMA. However, the EIA requires technologies such as wind turbines to be installed away from households to avoid noise or even switching off the turbines during certain periods of the year (Sustainable Energy Africa, 2017).

4.2.6 Social issues

Successful transitioning to RE depends on social perceptions and attitudes from local communities, stakeholders and policymakers. The strictness and institutional dedication to promoting market value chains may depend on the perceptions of top management in the municipality. The same applies to the adoption of RE technology, which may encounter some taboos and resistance, as was the case with biogas energy in Nepal (Yaqoot et al., 2016). The biogas project failed in Indonesia because of local taboos, and the same applies to the use of cooking fires in Nepal. Some investors may not be willing to invest in businesses under high-risk political and economic environments (Averchenkova et al., 2019). Therefore, this section describes social issues that need consideration for the successful implementation of RE at the municipal level.

South African communities have a positive perception of the use of RE, which could be triggered by pressing energy poverty issues. The DMRE conducted a household survey in 2013 and found that there is a positive perception of their access to energy, with an average means score for the Electricity Satisfaction Index (ESI) of 63.8 out of 100, ranked second after

social grants (DMRE, 2013). A study done in Bergville, South Africa, showed that people are willing to adopt and pay for new technologies, such as solar sources, regardless of knowledge about climate change. Despite showing a positive perception of RE, people lack adequate knowledge of the benefits associated with its use, which might impact the adoption rate. For example, a survey by DMRE (2013) showed that only a few of the studied population (37%) understood that switching from conventional electricity to solar would save them energy costs. Therefore, awareness campaigns are needed to educate people on the importance of using RE, as suggested by DMRE (2013), concerning the Energy Awareness Index (EAI) on energy saving in South Africa.

Besides positive perceptions of adopting RE, local municipalities need to address various drawbacks. These can be socio-cultural, like displacement from culturally inherited land, perceived environmental pollution, trust issues on the technology developers, distortion of the social fabric and community development (Amigun et al., 2011). In some cases, the most suitable site for effective energy harvesting and storage might be traditional land with cultural history for respective communities. Displacing people from such areas may trigger resentment and rejection of projects. According to Pasqualetti (2011), wind farms faced some resistance in the USA because people were scared of being displaced from their traditional land, and the same was reported from a study done by Amigun et al. (2011) on the Eastern Cape biodiesel project. The site selection process must be done in consultation with local communities and traditional leaderships and the Department of Agriculture Land Reform and Rural Development (DALRRD) to obtain communal land lease agreements (Mokone, 2020; Yaqoot et al., 2016).

Access to the RE for marginalised groups is of global interest. A study done in India by Pandyaswargo et al. (2022) recognises the need for equitable access to energy in off-grid rural areas; hence, they used several sustainability parameters, including social assessment, to design an appropriate RE system for off-grid areas. This consideration means that technology design must not overlook social issues such as acceptance and attitudes, which determine the specific applicability of a technology. Based on their findings, a people-centred private-public partnership business model and enabling policy and regulatory environment are crucial for RE's success. An empirical study was done by Li et al. (2023) to assess the effects of socio-economic productive capacity on RE development within the countries of Brazil, Russia, India, China, and South Africa (BRICS). The authors suggest the integration of productive assets, business skills, industrial linkages and policymakers to boost the socio-economic potential of renewable energy. It implies that transformative approaches integrating various stakeholders in a transdisciplinary innovation platform are needed rather than working in silos.

One of the reasons for public rejection is the lack of awareness of the importance of RE technologies, in this case, their contribution to energy security and social and economic development (Naicker & Thopil, 2019). South Africa is a country that has a sensitive historical background where some ethnic groups who were displaced in marginalised areas lacked access to basic services and are living within high poverty lines. Mirzania et al. (2023) describe the concept of energy transition in terms of socio-technical and socio-political dimensions, highlighting these factors as crucial for promoting the transition to RE systems. These authors propose the just transition feasibility framework to evaluate how feasibility constraints may affect the South African RE transition ideology and its commitments to energy justice. The authors challenge the REIPPP that it triggers energy vulnerability and misrecognition of places. Energy vulnerability refers to a group of people who are currently living in energy poverty and are likely to face energy insecurity. Therefore, the authors propose a change in South African energy policies by realigning the minerals energy complex to just transition in terms of the RE electrification program, community development and empowerment and sustainable socio-economic structures. The implementation of the REIPPPP program also brought with it several socio-economic problems, such as the loss of diverse perspectives on the roles played by government officials, foreign investors, and community representatives (Herbst & Lalk, 2015). Sharma et al. (2023) took an in-depth global examination of the green energy transition with a focus on green hydrogen. They explain the need to establish socially sustainable energy structures that are cost-effective and stable. These structures will meet SDGs such as affordable and clean energy as well as increasing human welfare, reducing inequalities, employment creation, sustaining cities, climate change mitigation and reducing poverty in alignment with the South African Local Government Association (SALGA) Energy Efficiency (EE) and RE strategy (SALGA, 2021).

Acknowledging these factors, the government has enacted robust policies to promote a just transition across all economic sectors, including energy accessibility. The IRP aligns with constitutional rights to ensure RE contributes to energy security for disadvantaged groups (DMRE, 2019). Additionally, energy initiatives must address the socio-economic concerns outlined in the NDP, such as employment generation, skills development, and rural advancement (Naicker and Thopil, 2019). Municipalities can play a crucial role in leveraging community resources to lead RE awareness campaigns.

The issue of social perceptions is not only limited to local communities but also to stakeholders involved. The RE investors are attracted when there are low investment risks driven by several factors such as a conducive political environment, evidence-based information on technological capacity, enabling policy environment creating viable markets for RE and institutional arrangements within the country. Nel (2015) carried out a multistakeholder study

to understand stakeholder perceptions towards introduction and investments in RE. The stakeholders were mainly academics and private and public sector employees. From their perspective, investment in RE may be risky due to structural challenges such as the lack of market forces, decision-making, and planning. The authors found that the perceptions of stakeholders indicate the lack of consensus on the roles and responsibilities of various stakeholders. They suggested representative stakeholder participation through varied stakeholder appointments, building consensus through public awareness and clarification of policies and goals. Lastly, the government should guard against actions that may lead to politically based risks or losses.

Municipalities must overhaul their institutional structures and enhance their credibility with investors. Akhtar et al. (2023) report that top management awareness plays a mediating role in the relationship between institutional and market factors. Cleaning out unethical issues that are creating more risks in RE investments can be counteracted by regulations to bring perpetrators to accountability and implementation of a Just Transition Tribunal (JTT) to prosecute perpetrators (Mirzania et al., 2023).

4.2.7 Policy, institutional and regulatory issues

Enabling policies and a robust legal and regulatory framework provide a foundation for the smooth operation of RE initiatives. South Africa has established strong policies and legal structures to support the transition to RE in a manner that fosters equitable economic development and creates a favourable environment for sustainable businesses. The South African Constitution (Act No. 108 of 1996) enshrines rights that align with the National Energy Policy (DMRE, 2019), including the right to a healthy environment. The White Paper on Energy Policy (1998) outlines a comprehensive legal framework for the energy sector, emphasising emission reduction, improved energy access for marginalised communities, enhanced governance, economic stimulation, health management, and supply security through diversification.

There are programs in which municipalities can leverage funding and support for RE in both on-grid and off-grid areas. The Integrated National Electrification Programme (INEP) is a South African Government non-grid policy to help finance Eskom and municipalities to clear up electricity backlogs as per the White Paper policy (SALGA, 2021). The recently launched South African Just Energy Transition Investment Plan (JET-IP) sets out the scale of need and the investments required to support programs linked to decarbonisation. The program was set up to explore zero carbon technologies such as green hydrogen, spearhead a transition in the energy sector by protecting vulnerable groups from coal and other fossils related emissions, implement rigorous approaches for creating an enabling policy environment and define the

role of the private sector, promote local energy chains from micro to medium enterprises thus stimulating local economic development and create a low emission economy through opportunities for technological innovation and private investment.

The issues of grid integration and energy storage are vital in the transition to RE. South Africa is facing an energy crisis characterised by extensive blackouts, putting economic development at risk as well as losses in local and foreign investors whose businesses are affected. However, there are policies to promote a smooth transition to RE by enhancing battery storage value chains. The South African government's DTIC, DSI and DMRE, in consultation with civil society groups, the private sector and research institutions, came up with SAREM (DMRE et al., 2023), which focuses on enhancing RE and battery storage value chains in support of the transition process for societal benefits and contribution to economic revival.

The bidding process for the implementation of RE at scale can be done rigorously and transparently, ensuring that it aligns with the government's economic development structures. The REIPPPP is a government-led bidding program initiated in 2011 to allow a rigorous selection process for RE service providers (DMRE et al., 2023). This programme provides an opportunity for municipalities to bid for energy production and sales as a service provider as stipulated in the SALGA strategic plan.

The government has legislation to regulate the distribution of electricity from producers to the grid and customers. The Electricity Act (Act 41 of 1987) mandates that NERSA control electricity distribution, marketing, and tariffs. All the uses of more than 5GWh per annum must register with NERSA (DMRE, 2019). They regulate the quality of supply, mediate disputes and address customer complaints. There are regulatory reforms that have been done since 2021, which include loosening up the registration process and removing the licensing requirement of IPP (DMRE et al., 2023). In addition, SSEG has been allowed to provide electricity to the grid, and they have been incentivised in some municipalities.

4.3 Summary

Assessing the feasibility of RE implementation in South African municipalities, solar and wind energy stand out as the most technically viable options, given the country's climatic conditions. The Northwest province offers significant solar energy potential, while coastal areas in Western, Eastern, and Northern Cape hold promise for wind energy. Additionally, biomass energy presents an opportunity for energy generation, leveraging organic waste from landfills, agriculture, and municipal sanitation systems.

The current South African policies have opened opportunities for energy generation and sales from small to medium independent power producers, which will increase energy production and the need for channelling into the grid. Integration of electricity into the municipal, national and international grid needs is possible if the existing Eskom infrastructure receives maintenance backlog and expansion to accommodate more energy streams. There are times when energy is produced in excess, so lithium-ion batteries are the most ideal for large-scale energy storage. However, more research is being done on green hydrogen storage options.

Most RE technologies are economically feasible in terms of returns on investments if production is done at economies of scale, proper tariffs are set to meet production and wheeling costs, and more subsidies are channelled towards RE material costs. Although municipalities are financially constrained, they can operate RE systems through PPPs.

The use of RE is environmentally friendly and is one of the approaches to climate change mitigation strategies. The use of solar and wind energy provides clean energy with less emissions compared to coal-based energy production. The only environmental issues of concern include noise pollution, the death of birds from wind turbines, and the disturbance of natural habitats.

Social perceptions and attitudes from local communities, stakeholders and policymakers play a role in the implementation and adoption of RE. Generally, people have a positive perception since they are energy insecure. However, the awareness level for the benefits of RE is very low. Transition to RE has social implications that should be considered, and these include displacement from culturally inherited land, perceived environmental pollution, trust issues with technology developers, distortion of the social fabric, and community development.

South Africa has strong policies and legal frameworks to support RE transition in a way that stimulates equitable economic development by providing a conducive environment for viable businesses. These include programs such as INEP, JET-IP and REIPPPP, strategies such as SAREM and legislation such as the Electricity Act 41 of 1987.

Key insights from the literature include:

- Advocating for a gradual implementation of RE.
- Granting municipalities autonomy in RE implementation.
- Recognising RE as essential for addressing national and international concerns such as climate change, resource extraction, energy security for future generations, and economic development.
- Emphasising the need for mandatory adoption of RE across all sectors.

- Highlighting the absence of established policies to regulate (SSEG) within local municipalities.
- Establishment and enforcement of policies to support political neutrality in RE implementation across municipalities.

5 SKILLS REQUIRED BY THE LOCAL GOVERNMENT SECTOR IN PROMOTING RENEWABLE ENERGY SYSTEMS

5.1 Introduction

The transition towards green energy needs strong capacity building in the local governments. It can be done through the development of new vocational programs and curricula, as well as education and training programs targeted at both upskilling and reskilling existing human resources (International Energy Agency, 2022). A global review by the International Energy Agency (IEA) reported an expected increase in green energy-related jobs, with the sector being estimated to create approximately 14 million jobs and train over 30 million people in the conventional energy fields. Currently, local municipalities human resources capacity to drive RE transition is characterised by poor labour structures (Adewumi, 2022), lack of interest in RE investments (Todd & McCauley, 2021a) and constraints to recruit competent labour forces (Adewumi, 2022). This section, therefore, aims to identify and describe skills required by local government for successful transitioning to RE. It will assess skills needed, describe capacity building in local municipalities and interaction with external stakeholders (communities, academic institutions and private sector) regarding skills requirements and provide recommendations for skills development through skilling and reskilling, academic curriculum change and collaboration with the international community.

5.2 Literature review

5.2.1 Assessment of skills needs

The local municipalities can collaborate with various stakeholders to assess existing and future skills needed in the RE sector. Skill assessment includes the identification of skills gaps, understanding how demanding various roles are, and understanding the need for technological improvement. This section describes important skills needed for RE. The skills were identified based on challenges that the South African local municipalities face with implementing RE (see **Error! Reference source not found.**). Major skills required include policy lobbying, research and development, financial skills (leveraging funding and management), technical skills (operations, maintenance, manufacturing and installations), marketing (identification and enhancement of markets) and social skills (community engagements and public awareness).

Table 1: Skills required by local governments to transition towards RE and the policy recommendations

Challenge	Skills required	Reference
Policy barriers	Policy lobbying through evidence-based information generation	Apfel et al. (2021); Semelane et al. (2021); Averchenkova et al. (2019)
Regulatory barriers	Research and development to improve best practices and compliance	Heidari and Heravi (2023); Mungodla et al. (2018); Todd and McCauley (2021a)
Financial capacity	Economics skills for leveraging funding from other sources Top management skills in moderating financial activities for smooth running, accountability, and corruption mitigation. Marketing skills to advertise the reputation of the company to boost local and international investor confidence	Ali et al. (2023); Madumo (2015); SALGA (2021); Semelane et al. (2021)
Technical operations	Operation and maintenance skills for sophisticated technologies such as hydrogen power and wind generators Primary data collection of sustainability indications like quantifying solar or wind energy harvested, identification and implementation of smart monitoring technologies Manufacturing expansion skills for the energy storage sector	Mbazima et al. (2022); Mirzania et al. (2023); Todd and McCauley (2021a); DMRE et al. (2023)
Market dynamics	Identification and creation of local and international markets for the RE value chain by exploring the potential of other eco-innovations	Nel (2015); Pandyaswargo et al. (2022); Li et al. (2023)
Research and development	Engineering skills for technology process improvement, information data for decision making and policy lobbying.	Mirzania et al. (2023); Mbazima et al. (2022); SALGA (2021)
Community awareness	Social science background to understanding the best ways to deal with community dynamics like expectations, awareness and acceptance	Apfel et al. (2021); eThekwini municipality (2020); Averchenkova et al. (2019)

5.2.2 Capacity building

5.2.2.1 Technical training

The lack of technical skills in local municipalities is one of the challenges faced in the RE transition. Technical skills scarcity has been reported concerning operations of Landfill Gas Energy (LFGE) projects (eThekwini municipality, 2020; Mbazima et al., 2022), energy storage and grid integration (DMRE et al., 2023; eThekwini municipality, 2020; Thango & Bokoro, 2022), repair and maintenance (Apfel et al., 2021) and reporting and monitoring (SALGA, 2021). Literature underscores the need for technical skills in operating and maintaining wind energy, solar PV, anaerobic digestors and CSP technologies (Aliyu et al., 2018; Apfel et al., 2021; Averchenkova et al., 2019).

Enhancing the RE value chain is one way that local municipalities can create employment opportunities for local communities, increase trust to attract local and foreign investments, and improve resilience. For example, although biomass energy is deemed the least developed technology based on specific technology maturity parameters (Mbazima et al., 2022), there are potential opportunities around waste-to-energy value chains like biogas production and residue use for agriculture (Jogiat, 2014). In literature, the biomass value chain extends beyond initial expectations. For instance, anaerobic digestion digestate can be utilised to produce biochar, an emerging economically significant product with diverse applications, including livestock feed, wastewater treatment, medical uses, energy production, and soil amendment (Amalina et al., 2022; Basinas et al., 2023; Saini et al., 2022). Due to its diverse value chain, it can add value to the profitability of the waste-to-energy value chain. Therefore, the marketing department should understand the technical aspects of eco-innovations and provide market research for various products from RE value chains. Econometric models and environmental impact assessments should be correctly and thoroughly done to provide accurate information to assist local municipalities in decision-making. The municipality will need well-equipped staff with a strong economics background to conduct econometric analyses in alignment with value chains exhibiting strong market linkages (Li et al., 2023; Nel, 2015; Pandyaswargo et al., 2022).

The environmental department officer or RE manager must have adequate skills to gather information through collaborative research with academic institutions, fostering co-creation and co-testing of RE demonstration pilot projects and participation in transdisciplinary activities. eThekwini municipality (2020) confirmed that they do not have adequate technical skills for the operation and maintenance of RE. Staff training programs may help municipal employees with technical skills to run RE technologies sustainably in the long run. Mirzania et al. (2023) report that staff training is a long-term investment in the local municipality rather

than paying dividends to shareholders. If training is not provided to local municipality staff before implementation, infrastructural maintenance will be a problem. For example, solar water heaters imported from South Africa failed due to a lack of maintenance since there were no adequate skills (Akinbami et al., 2021).

5.2.2.2 Policy and regulation

Capacity building can be applied to the management level. Some policy barriers may impede local municipalities from implementing RE (Apfel et al., 2021), and these need to be addressed. Policy change is a complex process that requires high levels of engagement with governmental and political organs. Most local government officials lack skills within the top management to spearhead policy advocacy (Averchenkova et al., 2019). Top management, therefore, needs training on understanding legislation and policies related to RE implementation and skills to push towards policy change strategically. However, the policy lobbying process requires evidence from academics and other stakeholders, such as municipal fora. The management should be able to understand academic language and communicate it with high level. Thus, general background on renewable is needed.

Problem and dispute-resolution skills are required by top management to foster the implementation of existing policies. For example, corruption and political interests may impede the smooth implementation of RE policies to benefit the vulnerable groups as expected. In this regard, Mirzania et al. (2023) advocate that institutions should have enough capacity to set up structures and mechanisms to counteract political disputes and implement a coordinated institutional action plan on RE.

5.2.2.3 Financial management

Financial management skills are needed within local governments to leverage funding for RE infrastructural development and smooth operations and maintenance. Most studies have explicitly mentioned a lack of financial capacity as a major obstacle to RE implementation (DMRE et al., 2023; Heidari & Heravi, 2023). There are two common funding sources: private and public sector funding (Heidari & Heravi, 2023). Funding can be obtained from local microfinance companies and even international organisations such as the World Bank (Todd & McCauley, 2021a). Thus, stakeholder engagement skills are needed to leverage funding opportunities from public and private institutions and companies. Local municipalities need financial and economic modelling skills to identify economically viable RE projects in their area and project their financial performances for sustainability. A study done in Pakistan by Ali et al. (2023) shows that there is a positive relationship between financial management techniques and cash inflows and outflows, capital investment, capital costs and associated risk factors for the long-term development of solar projects in Pakistan.

5.2.2.4 Creating a knowledge-sharing platform

There are various platforms in which municipal officials can meet and share experiences in RE. According to SALGA (2021), relevant platforms for RE include the C40 group of cities, United Cities and Local Governments of Africa (UCLGA), International Local Government for Sustainability (ICLEI), Covenant of Mayors and the Earth Hour City Challenge. eThekwini municipality has been participating in the C40 group of cities, which has supported the creation of a strategic roadmap for RE (eThekwini municipality, 2020). At a local level, South African local governments have a municipal forum where meetings are held and experiences are shared (Mirzania et al., 2023). These platforms provide an opportunity for them to learn from international fora and share information for strategic planning in a way that is beneficial for skills development and top management.

5.2.3 Partnerships and collaboration

It is imperative to develop technical, legal and business skills to engage with IPPs. SALGA (2021) advocates for action towards developing the key skills and processes required to engage with IPPs. The recommended municipal unit managers or any energy champion within the local government receive support on skills development towards the development of practical guidelines in compliance with local legislation and municipal procurement processes. The guidelines for power purchase agreements (PPAs), implementation agreements, connection and system use agreements, wheeling agreements, and third-party access tariff development should be included.

Certain municipalities, such as eThekwini, have included up-skilling and capacity building for officials on RE in their strategic planning. According to eThekwini municipality (2020), their action plans include:

I. Creation of training databases made available by municipal organisations such as South African Germany Energy Program (SAGEN), SALGA, Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Association of Municipal Electricity Utility (AMEU);
II. Appointment of personnel for distributing newsletters to inform departments about upcoming training programs for staff to enrol;
III. Monitoring and tracking of staff that are attending programs and building upon progress made;
IV. Encouraging staff that attended the training to run in-house knowledge sharing.

5.2.3.1 International bodies

Developed countries from Europe have skills and expertise in state-of-the-art RE technologies and sought-after experience in managing such systems, from which local municipalities can benefit. According to a respondent (number 8) in an interview by Mirzania et al. (2023), countries such as Spain have skills and expertise in RE from which South Africa can benefit. The DMRE et al. (2023) confirm that building capacities in the RE sector through international collaboration can improve South African technological readiness and competitiveness in the local and export markets.

There are various international organisations that local municipalities can work with to upskill their staff. The GIZ is one of the Germany-based organisations that play a role in providing training and skills programs for local municipalities to transition more easily towards RE, and they are actively working with SALGA (eThekwini municipality, 2020; SALGA, 2021). SAGEN and GIZ worked with Development Environmental Affairs and Tourism (DEDEAT), which is currently the Department of Forestry, Fisheries and the Environment (DFFE), to support RE activities. They held over 20 workshops in 14 municipalities to conduct skills development programs in support of the REIPPPP (WWF, 2015). The International Renewable Energy Agency (IRENA) is another Abu Dhabi-based international organisation with significant experience in capacity building (Lucas et al., 2017).

5.2.3.2 Fostering innovation and R&D

Academic institutions play a pivotal role in skills development by generating new ideas through scientific research and innovation. However, this valuable information often remains inaccessible to local municipalities and is confined to academic papers and dissertations (GodfreyGörgens and Roman, 2020; MbazimaMasekameni and Mmereki, 2022). Collaboration between local municipalities and academic institutions can facilitate technology transfer, enabling municipalities to benefit from new knowledge for capacity-building purposes.

Innovation hubs are nodes or centres where communities and collaborators meet and demonstrate innovative energy ideas (Liaros, 2020). South Africa was reported to be underspending on technology transfer from RE. DMRE et al. (2023) highlight that 0.6% of GDP is used for Research and Development (R&D), which is more than the target of 1.5% for the year 2021. This area is lagging in technological maturity in terms of capacity building. Therefore, local municipalities should play a role in funding such living labs in collaboration with the Department of Science and Innovation (DSI). The DSI has held Industry-Meets-Science Workshops to strengthen Research Development and Innovation (RDI) relationships between industry and the R&D community and disseminate experiences and knowledge (Godfrey et al., 2020).

5.2.3.3 Collaboration with educational institutions

Capacity building can be implemented from high school level to tertiary institutions to create a pool of graduates with RE literacy. One of the SAREM proposed targets in the RE skills and development area is to increase the number of qualified graduates or skilled people (DMRE et al., 2023). Lucas et al. (2017) suggest that curriculum development within education programs can be a solution to capacity building. The other issue pertains to the absorption of graduates in the energy industry, where experience is very important. Yes4Youth has been mentioned in the SAREM as one of the trusted and beneficial platforms to promote the absorption of graduates into the RE labour markets (DMRE et al., 2023). Another challenge remains a mismatch between industry expectations and the quality of graduates from Tertiary Vocational Educational Training (TVET) colleges, universities, and training institutions, such as the Sector Education and Training Authorities (SETAs). If there is no proper industry guide on curriculum development, the mismatch poses a challenge for the development of current and future skills (DMRE et al., 2023). In addition, industries can support internship programs to promote the university-industrial linkage. For example, collaboration between Ashegoda Wind Farm and Mekelle University led to the launch of the Energy Technology Concentration Master's program, which was successful in Ethiopia (Chen, 2018).

5.2.3.4 Inclusive training

The energy transition process must prioritise the welfare of communities from marginalised areas, including those impacted by RE initiatives, such as coal production towns. The REIPPPP was initiated to align with the NDP, with a focus on community development and employment creation (Jain and Jain, 2017). However, a significant challenge persists: vulnerable groups, such as local communities, often only participate in the construction phase without long-term plans for their sustained benefit.

A study done by Nkoana (2018) revealed that the process of involving IPP is selective; it favours highly influential stakeholders to thrive at the expense of vulnerable communities. In addition, local communities work in low-skilled construction jobs which end after project commissioning. The same was reported by Mirzania et al. (2023); a shift from conventional ways of livelihoods for local communities to RE might come with job losses, and this should be avoided, as advocated by trade unions.

With that in mind, training local communities on the maintenance and repair of RE technologies can provide a long-term solution. Some respondents also raised this issue during interviews conducted by Mirzania et al. (2023). A case study done by Chen (2018) shows that a Chinese company (HydroChina) constructed wind farms in Ethiopia, shared their high level of expertise and experience with local engineers and scholars, and employed a larger share

of local community workers. This undertaking provided the host government with adequate capacity to maximise technology transfer.

South Africa is positioned as a key strategic area in the development of local capabilities, particularly in skills and technological innovation within the RE sector. This initiative is highlighted as one of the primary objectives of SAREM (DMRE et al., 2023). Apprenticeships and internships can be the solution to capacitate communities with hands-on experience in RE. SAREM is considering consolidating and expanding internship programmes in the RE and storage sector by participating in Yes4Youth. The program aims to increase the participation of the youth by 2030 (DMRE et al., 2023). In South Africa, the Jeffreys Bay Wind Farm has played a pivotal role in community development through enterprises that support emerging black-owned companies in the area, socio-economic support for healthcare access, early childhood development, numeracy and literacy assistance at the primary school level, supporting science and mathematics in high school and providing scholarship programs for engineering studies at tertiary level (Sustainable Energy Africa, 2017). Hence, local municipalities may explore avenues to promote inclusive local skills development through diverse channels. Nkoana (2018) proposes the establishment of a policy framework that prioritises vulnerable stakeholders as a long-term solution.

5.2.4 Public awareness and engagement

The RE sector encounters risks stemming from shortages in technical skills, further complicated by social tensions within communities. Public awareness is crucial in addressing these challenges. Mirzania et al. (2023) highlight that certain technical jobs within the RE sector demand extensive skills and knowledge yet are often perceived by local communities as simple tasks they can undertake. This perception leads to tensions and social resistance toward highly skilled foreign workers. Effective strategies for integrating skilled foreign labour into the workforce require robust community engagement and awareness initiatives.

Communities play a pivotal role in innovation and technology transfer, making their engagement essential from the outset to foster equitable and resilient technologies. Given that some infrastructure will be installed in local communities where social challenges like power theft, vandalism, and service delivery protests are prevalent, proactive measures are necessary. Nkoana (2018) recommends awareness campaigns and capacity-building interventions for local leaders and beneficiaries. In this context, competent community liaison officers are indispensable. They will facilitate awareness programs, strengthen connections between communities and the research team and stakeholders involved in RE projects, and help manage expectations (Sharma et al., 2023).

5.3 Summary

Major skills required include policy lobbying, research and development, financial (leveraging funding and management), technical (operations, maintenance, manufacturing and installations), marketing (identification and enhancement of markets) and social skills (community engagements and public awareness).

Skills requirements for RE within local governments depend on the position within the institution:

- Top management needs stakeholder engagement skills to influence policy change, create a strategic roadmap for RE, and moderate smooth institutional operations.
- The energy champion or unit manager needs a conceptual understanding of RE and stakeholder engagement skills to promote R&D in collaboration with academic institutions. They must also collect data to monitor and improve RE technologies.
- The business unit controls the economic and financial operations of the municipality. Therefore, they need stakeholder engagement skills to leverage funding for local and international sources, negotiate financially viable partnerships, and identify and enhance RE markets.
- The community liaison unit must ensure that just transition in the RE sector is implemented. They need skills in community engagement, managing expectations, rolling out awareness and coordinating community training programs.

6 INTERNATIONAL AND REGIONAL BEST PRACTICES FOR IMPLEMENTING SUSTAINABLE RENEWABLE ENERGY SYSTEMS

6.1 Introduction

This research project aims to implement international and regional best practices for RE systems in South African local government areas while reviewing relevant literature on the subject. RE sources such as hydro, solar, wind, biomass, and geothermal hold significant potential in South Africa. Despite an average global electricity access rate of only 54% in 2019 (Justo et al., 2022), ensuring energy access remains a critical policy concern for the nation. South Africa is strongly motivated by this low electrification rate to leverage more renewable resources and achieve universal electricity access (Justo et al., 2022).

To tackle the challenges of low electrification rates and GHG emissions, South Africa has implemented various methodologies, energy plans, and government programs (Sterl et al., 2021). According to the study, the adoption of RE sources is driving technological advancements that can lead to lower carbon emissions in the future. Solar, wind, and biomass energy sources remain abundant even with increased utilisation (Sterl et al., 2021). Sunlight, in particular, is a reliable energy source that can meet the world's growing energy demands. The study examines pertinent literature on global energy requirements, domestic RE technologies, and public perceptions of RE.

6.2 Contextualizing Renewable Energy Sources: Towards Sustainable Energy

RE is a topic that both specialists and the general public are becoming more concerned about. Studies on renewable energy sources (RES) have grown both significantly and proportionally during the past few years (Rizzi et al., 2014; Safwat Kabel & Bassim, 2019). To combat the concerns of global warming and the depletion of fossil fuels, RES can play a significant role (Momete, 2018). The three main sources of energy are nuclear power, fossil fuels, and renewable resources. To reproduce energy, RES like solar, wind, biomass, geothermal, and hydropower are used (Ahmad Ludin et al., 2021; Ashfaq & Ianakiev, 2018; Raheem et al., 2021). As a result, they are incredibly helpful in the fight against energy crises.

In Western Greek villages, a recent study (Paravantis & Kontoulis, 2020) examined public opinion and willingness to pay for electricity from RES. Because they are environmentally friendly, RES are regarded as a clean energy source (Xu et al., 2022) and are crucial. Traditional reliance on fossil fuels is said to have contributed to carbon dioxide (CO_2) emissions, GHG issues, and environmental pollution as environmental consciousness has

grown (Lucas et al., 2018; Simonic et al., 2020). RES can provide household energy needs while emitting virtually no air pollution or GHGs (Fornara et al., 2016).

The development of RE is anticipated to address important issues like the long-term sustainability of remote areas in desert and mountainside zones as well as the execution of obligations to fulfil international agreements about environmental protection (Stigka et al., 2014). There is currently a trend for RES to take the place of traditional fuels To address the excessive energy demand (Borovik & Albers, 2018). Due to several problems, including GHG emissions, CO_2 emissions, climate change, and energy security, RE is becoming increasingly necessary in the current environment (Bayulgen & Benegal, 2019; Zografakis et al., 2010).

RES provide economic benefits, environmental protection, and a pollution-free environment in contrast to fossil fuels. As a result, they must be used to meet the energy needs of both the current and future generations. Policy-making and public opinion research are essential to promote the adoption of RE. Analysing public opinion on RE is crucial as it can influence the formulation of policies. The study by Qazi et al. (2017) highlights the significant relationship between public opinion and public policy.

6.3 International Practices on the Sustainability of Renewable Energy Systems

Sustainability is a broad notion that incorporates at least three aspects, namely, society, economics, and the environment. Compared to just 48 nations in 2005, 128 countries had approved RE assistance policies by 2017 (Xie et al., 2022). These policies were essential in supporting countries in making the move from conventional to RE by reducing the barriers to the growth of renewable energy. For both land-based and maritime weather applications, meteorological data are systematically recorded (Sørensen, 1995). Solar and wind resources have only ever been investigated through distant sensing and modelling for the majority of the Earth's surface up until this point and methods for numerical weather prediction (NWP).

Before the 1970s, the majority of solar provisioning models were created "for low-temperature solar applications and did not require the high temporal and spatial resolutions today necessary for effective solar power integration" (Kaur et al., 2016). Similarly, wind speed measurements for electricity production were not required at heights above 25m before the 1980s, when the majority of wind turbine blades were 20m or less in length (Oyewo et al., 2022). The rapid market share growth of wind and solar generation over the past 20 years (Dong et al., 2020; Inman et al., 2013) led to "the development of wind and solar forecasting methodologies with forecasting horizons ranging from minutes to several days ahead".

Although the field of forecasting in RE is still young, significant progress has been made over the last ten years. However, given "the variety of global conditions, further development calls

for the systematic evaluation of methodologies that are challenging to compare with only a few accepted error metrics" (Dong et al., 2020). Numerous methodological orientations, historical eras, and geographical locations have been used to study the consequences of renewable energy.

The majority of the studies concluded that policies used to transition to RE were essential in lowering carbon emissions considerably and that RE had a positive relationship with economic growth, the creation of jobs, and welfare (Lobo, 2017). The power system is the principal cause of GHG emissions that threaten environmental sustainability (Rathore et al., 2018). In addition, it generates the energy sources needed to enable long-term social and economic advancement.

Driven by the deteriorating ecological environment, societal change, and the resulting public interest, sustainability is becoming a popular issue of discussion among the general public, governments, businesses, and academic experts. In the 1987 United Nations report "Our Common Future", one of the most widely accepted tentative definitions of sustainability was given. It reads as follows: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

Numerous sustainability-related dimensions have been developed and researched since that time. In the late 1990s, the British scholar Elkington coined the phrase Triple Bottom Line (TBL), which evaluates sustainability by combining the three factors of economic, environmental, and social sustainability. To put it another way, organisations looking to grow need to strike a balance between promoting social welfare, protecting the environment, and generating income (Elkington, 2006).

6.4 The Dimension of Sustainability for Renewable Energy

The environment is the focus of the first sustainability dimension. Environmental concerns have grown increasingly important since the 1980s for global sustainable development. According to Goodland (1995), environmental sustainability refers to preserving natural resources and making sure that the capacity to handle human waste products responsibly is not exceeded. Environmental sustainability, according to Diesendorf (2000), requires that natural resources not be depleted more quickly than they can be replenished. Society is the focus of the second sustainability dimension. Equity, empowerment, accessibility, participation, cultural identity, and institutional stability are all parts of social sustainability (Daly, 1992).

Saith (2006) argues that social sustainability must be promoted on a worldwide scale through the use of proper healthcare, education, gender equality, peace, and stability. The third

component is economic viability. Economic sustainability, according to Lobo (2017), is defined as a production system that satisfies the present level of consumption without jeopardising future demand. Traditional financial performance and external economic advantages are two different facets of the economic dimension of sustainability, according to Sheth et al. (2011). The power system significantly impacts the sustainability of the environment, society, and economy.

Firstly, in terms of environmental sustainability, the overreliance on fossil fuels leads to more than 40% of global carbon emissions, significantly impacting climate change (Watch Climate, 2021). Additionally, emissions from other gases generated by the power system contribute significantly to air pollution, as seen in China's coal-fired power plants, which cause hazardous haze (Spegele & Abkowitz, 2015).

Secondly, regarding social sustainability, the power system's reliability affects various aspects of people's lives. Any collapse in the power system poses severe risks to the health and well-being of individuals and communities. For example, during a blizzard in Texas, millions experienced power outages, exposing them to cold and darkness (Busby et al., 2021).

Thirdly, the power system plays a crucial role in economic sustainability by providing the energy necessary for contemporary economic growth. There exists a clear causal relationship between a nation's economic prosperity and the production and utilisation of electricity (Shiu & Lam, 2004). Understanding the comprehensive impact of the power system on sustainability and performance management is essential. Therefore, conducting a thorough literature analysis can provide valuable insights into evaluating the sustainability performance of the power system.

6.5 Impact of Renewable Energy on Economic Growth

The use of RE and economic conditions were examined between 1990 and 2010 for the OECD regions using a Pedroni cointegration test. According to the analysis, increasing the consumption of RE by 1% will result in increases in GDP and GDP per capita of 0.105% and 0.100%, respectively, while increasing the share of RE in the countries' energy mix will result in GDP increases of 0.089% and 0.090%, respectively. In a few OECD countries, Shafiei et al. (2013) looked at how consumption of renewable and non-RE affected economic growth. The study was conducted between 1980 and 2011.

The study demonstrates that, both in the short and long terms, there is a bidirectional causal relationship between economic growth and both renewable and non-RE consumption. They conclude that the main energy source for the process of economic expansion is still non-renewable resources. Several studies have looked into the relationship between the use of

RE sources and economic growth using the Auto-Regressive Distributed Lag (ARDL) approach. For instance, Maji (2014) assessed the long-term correlation between RE indicators and economic growth in Nigeria using the ARDL method. The study found a significant and unfavourable relationship between nuclear and alternative energy and economic growth.

The study stresses the lack of a distinct legal and administrative structure in charge of RE and urges Nigeria to push for the development of RE sources. Taghvaei et al. (2017) investigated "the relationship between economic growth and energy consumption in Iran from 1981 to 2012 using the Auto-Regressive Distributed Lag (ARDL) model". The study concludes that RE does not promote economic growth in Iran. They suggested that the Iranian government implement measures to encourage the use of RE in light of the low prices of fossil fuels, which limit the growth of renewable energy.

6.6 Renewable Energy Systems in the Global Context

In South Africa, other authors examined the causal link between the use of RE and economic growth (Khobai & Roux, 2017). Their study uses trade openness, capital formation, and carbon dioxide emissions as "additional variables to create a multivariate framework. Using quarterly statistics covers from the years 1990 to 2014". The researchers used the "Autoregressive distributed lag (ARDL) technique to look at the long-term relationship between the variables and the Vector Error Correction model (VECM) to determine the direction of causation between the variables" (Khobai & Roux, 2017).

The following study's findings suggested a long-term growth theory and a short-term conservation hypothesis. Silva et al. (2012) investigated how the percentage of RE sources impacted the GDP and CO_2 emissions used in power generation. Four nations (Holland, Portugal, Spain, and the USA) were chosen as a sample to invest in RE earlier on; social and economic issues were considered, although they reflect slightly different rates of economic growth.

The usage of additional RE sources in power generation between 1997 and 2006 was shown to cost Holland, Portugal, and Spain money in terms of GDP per capita and a decrease in CO_2 emissions per capita. The cost of RES support may be lowest in the USA. The eThekwini municipality (2020) report recommended that the governments of Denmark, Portugal, and Spain utilise other measures, like demand-side management and energy conservation, that could help achieve environmental goals at the lowest possible cost. However, using a neoclassical growth function that includes capital, labour, and energy use as additional input parameters allows for a more comprehensive analysis.

According to Philipp and Georgeta (2018), the MENA region's economic growth was significantly and favourably impacted by the production of renewable electricity. Because such investments are good for the region, the report advised MENA countries to tighten their current policies in favour of renewable energy. Bhattacharya et al. (2016) used panel estimate methodologies to investigate how the consumption of RE affected economic growth in 38 of the top countries from 1991 to 2012.

The long-run output elasticities show a significant positive correlation between RE usage and economic output of 57% in the studied nations. While the use of non-RE has historically contributed significantly to India's economic growth, Ohlan (2016) argues that the adoption of RE has had the opposite effect. Ohlan claims that RE usage showed a statistically insignificant relationship with economic growth from 1971 to 2012.

6.6.1 Impact on job creation

Numerous studies evaluated the impact on employment creation of investing in RE systems as opposed to fossil fuels (Bulavskaya & Reynès, 2018; Justo et al., 2022; Oyewo et al., 2022). Using an input-output model, Haerer and Pratson (2015) calculate that between 2008 and 2012 in the United States, the natural gas, solar, and wind industries added around 220,000 new employment while the coal industry lost approximately 49,000 jobs. Almost three times as much employment is created by energy efficiency and RE sectors for the same amount of investment, according to Garrett-Peltier's research from 2017 (Garrett-Peltier, 2017).

This research noted that 2.65 full-time equivalent jobs were typically created for every $1 million spent on fossil fuels, whereas 7.49 or 7.72 full-time equivalent jobs were frequently created for every $1 million spent on RE. In the US, the solar business employs more people than coal in the area of producing electric power (Oyewo et al., 2022), St. According to DMRE (2017), around 374,000 people, or 43% of the workforce, were employed by the electric power generation sector in 2016, compared to 187,117 persons, or 22% of the workforce, by traditional fossil fuels.

Bulavskaya and Reynès (2018) note that wind and solar power generation require more capital and labour than fossil fuel power plants but utilise less energy. As a result, they are more valuable to the national economy than power generated using fossil fuels. According to the report, the Netherlands' switch to RE will result in the addition of around 50,000 new jobs and 1% by 2030. When compared to gas and coal plants, wind and solar technologies have a higher labour and capital intensity. Over 440,000 jobs were lost in the fossil fuel sector between 2015 and 2016 as a result of low oil prices and an oversupply (IRENA, 2017).

Other studies assess the employment brought about by RE using a range of techniques. Using an adjusted input-output-analysis from 2005 to 2010 GIZ (2012) calculated that national sustainable energy projects for Tunisia resulted in the creation of 2,500 direct jobs. Silva et al. (2013) used input-output analysis to predict how Portugal's employment will change as a result of the rise of RE sources. The findings show that implementing RE technologies has an immensely favourable effect on employment.

According to Markandya et al. (2016), the switch from more carbon-intensive energy sources to gas and RE sources resulted in the creation of 530,000 new jobs between 1995 and 2009. In line with this perspective, in a recent study by Mu et al. (2018), the authors argue that by increasing solar PV and wind power by 1 TW h, the Computable General Equilibrium (CGE) model predicts that China might create up to 45.1 thousand direct jobs and 15.8 thousand indirect jobs, respectively. Green energy policy, according to Markandya et al. (2016), can have both good and negative effects on employment, as it would compete with investment-induced employment in other sectors while also producing more green jobs.

When labour taxes are used to pay for subsidies to electricity production from RE sources, a negative effect results (Böhringer et al., 2013). Both gross employment and net employment must be considered to calculate the employment impact of renewable energy. Gross employment is the total of gains in employment as a result of investments in RE sources; it does not consider any job losses in other industries. Both positive and negative effects are considered by net employment (IRENA, 2017).

According to IRENA (2017), the government should adopt policies to promote the creation of jobs related to the development and deployment of renewable energy, taking into consideration the accompanying opportunity costs and weighing them against the anticipated benefits. The relevance of labour market regulations in promoting the growth of RE sources is also highlighted by (Blazejczak et al., 2014). The net employment effects of developing RE depend heavily on the state of the labour market.

By 2030, there may be 24 million jobs related to RE worldwide, according to IRENA (2017a) IRENA (2017). Globally, the RE industry has the potential to provide around 25 million jobs by 2050. Furthermore, more jobs are projected to be created in the energy efficiency and renewable industries than would be lost in the conventional energy industry (IRENA, 2017).

6.6.2 Impacts on the cost of electricity

Blazejczak et al. (2014) use the ISO-NE power system’s production cost model to analyse the impact of wind energy on electricity costs. According to the study, rising wind penetration results in lower electricity costs and increased electricity price volatility. The impact of wind

energy on volatility is greater in the short run. Ketterer (2014) discovered a comparable finding for Germany but emphasised the danger of constructing new plants due to the unpredictability of the profitability of conventional or renewable power plants, which has a significant impact on the energy market and supply security. The production of solar and wind energy has had a significant economic impact on Germany and Denmark (Rintamäki et al., 2017).

Pham and Lemoine (2020) estimated the effect of subsidised renewable electricity on spot prices in Germany using the GARCH model in a panel data framework. Their analysis discovered that the production of wind and solar energy decreased electricity spot prices and increased volatility between October 2009 and December 2012. RE's overall merit order effect ranges from €3.86 to €8.34 per megawatt hour. According to Ciriminna et al. (2016), solar PV and wind energy have a favourable effect on power prices in Sicily. The high penetration of RE sources in 2015 caused Sicily's zonal power price to fall below Italy's national wholesale price.

Using panel data, Trujillo-Baute et al. (2018) investigated the effects of assistance programs for electricity from RE sources on retail electricity prices for families and industrial consumers in the EU nations from 2007 to 2013. According to their findings, the expenditures associated with promoting RE have a positive and statistically significant impact on retail electricity prices. However, this effect is minimal in comparison to other variables. A 1% rise in the price of promoting RE consumption of non-RE raises industrial retail prices by 0.023% and residential as well as retail prices by 0.008% (Oyewo, Bogdanov, Aghahosseini, Mensah & Breyer, 2022).

According to Paraschiv et al. (2014), Germany's energy day-ahead costs decreased as a result of the development of wind and solar power. According to Gianfreda et al. (2015), the increase in the hourly average of daily production from solar and wind sources by 1 GWh led to decreases in the wholesale pricing of energy in Italy of 2.3€/MWh and 4.2€/MWh, respectively. Using a hybrid study, Gullì and Balbo (2015) look into how PV generation affects Italy's wholesale electricity pricing.

The findings suggest that when paired with other factors, PV energy growth can lower electricity prices. Pereira et al. (2017) analyze the impact of wind generation and hydro availability on the price of energy in Spain using an ARX-GARCHX model. The availability of hydro energy lowers the volatility of power costs, but wind energy increases the volatility, according to a study conducted from 2007 to 2014. Safwat Kabel and Bassim (2019)compared the effects of four different types of RE and energy efficiency, demand-side management (DSM) base, DSM peak, solar PV, and wind on public health and climate in six different locations throughout the Mid-Atlantic and Lower Great Lakes of the United States using the Environmental Policy Simulation Tool for Electrical grid Interventions (EPSTEIN) model.

The report estimates that the annual benefits might range from US $5.7 million to $210 million. Haq et al. (2020) reveal how the use of solar energy in underdeveloped countries dramatically improves people's income, social life, health, and capacity to adapt to climate change. According to Gibon et al. (2017), the bulk of RE sources are superior to fossil fuels, particularly coal.

6.6.3 Effects on imports of fuel

America's reliance on imported fossil fuels has decreased as a result of the increased role that wind power plays in the country's energy mix (Hager & Hamagami, 2020). According to Arapogianni et al. (2014), switching to wind energy generation from fossil fuels can lower reliance on domestic and imported fuels while also lowering GHG emissions and the cost of fuel imports. They analysed the dynamics of imports concerning the production of RE using import demand equations. Their report emphasised the significance of producing RE for the economy in lowering its dependence on foreign countries and debt by slowing the increase of imports.

Germany's switch to RE in the power industry, according to Banks et al. (2015), prevented the nation from importing €11 billion worth of fossil fuels from 2009 to 2012. Valodka and Valodkienė (2015) estimated that Lithuania's increased use of RE would result in savings of €278 million in fuel imports per year.

6.6.4 International best practices

The transition towards RE is gaining momentum worldwide due to the evident need to mitigate climate change and address future energy demands sustainably. The transition to RE sources and low-carbon technology is greatly aided by climate research. Demand for cleaner, more sustainable energy is rising as awareness of the need to combat climate change rises. Globally, there is a fundamental shift taking place in the energy sector toward the procurement of greener, more sustainable energy, which still needs to be equally as secure as energy production from conventional fossil sources.

Energy generation from renewable, virtually limitless sources like wind, water, sun, biomass, or geothermal energy is a key component of environmentally friendly energy systems. Energy supply must always be assured during this transition to RE sources. A wide range of technical solutions are needed for this. Renewable energy technologies do face some difficulties. In many ways, getting energy from renewable sources is difficult. Considering the enormous volume of energy sources, their distribution, voltage ranges, and energy production, all of which can vary greatly depending on the time of year.

As a result, energy generation systems need to be adaptable and smoothly interact with regional storage systems. Local governments play a vital role in promoting and implementing RE systems within communities. This section examines international and regional best practices for the effective implementation of RE systems in the local government sector.

6.6.4.1 Germany

6.6.4.1.1 National and EU policy framework

The German government has set high goals for the energy transition, including a 95% decrease in GHG emissions (from 1990 levels) by 2050 and an 80% proportion of RE in gross power consumption. A complete nuclear power shutdown by 2022 and a 65% proportion of RE by 2030 are among its medium-term objectives (Schiffer & Trüby, 2018). Two federal statutes serve as the foundation for German RE policy. Small energy producers were given guaranteed connection to the grid under the Feed-In Law of 1990. This system was stabilized by the Renewable Energy Act (Gründinger, 2017), which also gave producers of RE a 20-year feed-in price guarantee.

The 2000 EEG guaranteed priority grid access for RE generators and abolished the cap on the growth of RE. The EU has undertaken efforts to encourage harmonization in the development of RE sources and the construction of a European energy market, even though individual member states still retain a great deal of autonomy in energy policy. The energy sector's deregulation, which was completed in the 1990s, was mandated by EU authorities. The main German energy corporations' regional supply monopolies were broken up as a result, but the sector was consolidated into four even bigger companies after that.

To promote market competition, the European Commission has more recently pressured Germany to phase out its FIT in favour of competitive auctions for future RE projects. Furthermore, Germany's planned transition from a clear dominance of coal, oil, and nuclear to a low-carbon, nuclear-free economy based on the use of renewable sources is known as the 'Energiewende'. By 2050, it is anticipated that CO_2 emissions will have decreased by 80% and that RE will account for 60% of all energy use. Investments in projects for offshore wind, PVs, grid extension, and energy storage will be crucial, as will the construction of a new, smart energy infrastructure that can balance the irregular supply of renewable sources.

For South Africa, using less energy will be essential. For many years, Germany has been at the forefront of the global adoption of environmental and RE technologies. However, to ensure the security of its electrical supply, Germany has kept a sizeable quantity of oil and natural gas on hand. Due to a lack of natural resources, the energy sector is highly dependent on imports. We import the majority of the oil and gas we utilise. These dependencies have led to two unstable scenarios. Firstly, changes in international pricing have a considerable influence on

German energy importers and consumers. Secondly, Germany's relationship with specific countries, particularly Russia, has a big impact on how the market develops.

It will be even more important to continue trying to diversify gas supply options, particularly through the importation of liquefied natural gas, as the simultaneous phase-outs of coal and nuclear power are predicted to increase the country's reliance on natural gas. Although the amount of RE being used to power the system has been steadily rising, there have not yet been any notable instances of power outages. Due to Germany having one of the lowest rates of power outages globally, both commercial and residential consumers can count on a steady, uninterrupted energy supply.

In 2020, it was predicted that there would be about 90,000 businesses with over 245,000 workers and an estimated $408 billion in revenue. The top five energy corporations in terms of overall revenue are Uniper Global Commodities SE, E.ON SE, EnBW Energie Baden Wuerttemberg AG, Statkraft Markets GmbH, and Tennet TSO GmbH.

6.6.4.1.2 Local government's role in Germany's federal system

German municipal businesses are involved in the energy industry. According to a study conducted by the German Association of Towns and Municipalities, many local public firms' financial situations have become worse, which has had a negative influence on local governments. Since then, municipal organisations have pleaded with the national and state governments to support these neighbourhood energy initiatives.

Germany is divided into 16 federal states. The state (Länder) level administrative framework includes local administrations. The federal government (Bund) and the state governments share statehood. Local governments do not make up an autonomous third tier of government because of the constitutional guarantee of local self-governance provided by Article 28 (2) sentence 1 of the German Constitution. Local governments are referred to as "indirect state administrations" due to their limited legal autonomy. While acting as autonomous units, they also carry out Bund and Länder laws. The Basic Law (BL) gives the Länder, where local governments perform most of the administrative duties most of the administrative responsibilities. In some circumstances, local administrations also serve in a dual capacity as state authorities (Kuhlmann et al., 2008).

6.6.4.1.3 Regulatory environment for municipal business

Germany has a long history of local governments engaging in business activity. For instance, the Association of Municipal Enterprises (Verband Kommunaler Unternehmen, VKU) comprises more than 1,500 member businesses that are principally engaged in telecommunications, waste management, water and wastewater management, and energy

delivery. Together, they brought in over €123 billion in 2020 in sales income. Public enterprises are neither either recognised nor explicitly forbidden by the BL (GIZ, 2001).

However, certain articles of the BL, such as 87e (3) and 87f (2), allow public agencies to function cost-effectively. The state's entrepreneurial activity, however, must serve a public purpose, just like any other official activity, because it should only be seen as a way of carrying out state duties. Therefore, according to constitutional law, engaging in commercial activity only to make money is forbidden (Kuhlmann et al., 2021).

The provision of energy supply is one of the distinctive duties of local governments relating to services of general interest, according to the Federal Constitutional Court (BVerfG) (BVerfG NJW 1990, 1783). This duty is the responsibility of the municipality and is regarded as an issue of the local community under the constitutional guarantee of local self-government in Article 28 (2) sentence 1 of the Basic Law: "The right to local self-government ensures local governments' autonomy in choosing how to structure its internal administration and, consequently, in choosing to carry out tasks through entrepreneurial activity". Local government regulations, which fall under the purview of the federal states' legislative authority, place restrictions on this privilege. As a result, each state has its definition of this right's exact reach.

Three requirements must consistently be followed for municipal economic activity to be legal, per the municipal codes of the federal states:

- The main requirements for economic activity by municipalities are that it serves a public purpose, maintains an adequate relationship to the municipality's capability and anticipated needs, and that the purpose to be fulfilled by a municipal enterprise is not or cannot be fulfilled better and more economically by another (private) party.
- Federal states implemented legislation several years ago to simplify municipal action in the energy sector, particularly on a supra-local basis. Technical and economic advancements occurred concurrently with these legislative changes. Due to the increased use of renewable energies and technological advancements, decentralised structures are progressively replacing the traditional centrally controlled energy supply system. This change can be partly ascribed to the choice to phase out nuclear power as well as the adoption of policies meant to safeguard the environment.
- Municipal energy enterprises used to be primarily concerned with the distribution of energy (running an energy supply network). However, today, they are also engaged in the acquisition and production of primary energy sources and the delivery of a wide range of functionally related services (Kuhlmann et al., 2021). In 2021, energy imports accounted for almost 64% of the total energy available. Natural gas imports made up

95% of the total, making them the most significant source of energy for both private consumers and businesses (Demirbas, 2006).

As mentioned above, the aggressive expansion of RE sources is essential in the medium and long term for both preserving the climate and lowering reliance on imported energy. The current objective is to guarantee a reliable and economical energy supply. Municipalities, their companies, and the active participation of residents in fostering acceptance all play a significant part in this. This participation makes it even more important for the federal and state governments to provide cities with the support they require to make upcoming investments in the energy sector.

The lesson from the best practices of RE system implementation in Germany is crucial for local adaptation in the South African local government context. Germany has achieved remarkable success in adopting RE by implementing a combination of supportive policies and incentives. The country's FiT scheme guarantees fixed electricity prices for RE generators, fostering investor confidence. Additionally, policies promoting citizen participation in RE projects have empowered local communities and reduced reliance on external actors.

6.6.4.2 Japan

In Japan, established utilities opposed the decentralisation of the energy system by citing issues with regional grid compatibility, supported by the strong Ministry of Economics, Trade, and Industry (METI). To limit local energy access to the national grid, the national government has continued to collaborate closely with major utilities, giving them a lot of the responsibility for managing electricity transmission and distribution.

Local environmental activists have failed to generate self-reinforcing momentum. To promote local electricity retailing, however, and covertly oppose the previous utility paradigm, they have started to take advantage of the deregulation of the electrical market. Opportunities for community initiatives are altered by policy change at higher levels of governance, and vice versa. This relationship has made the energy transition in Germany into a competition between centralised and decentralised models (Hager & Hamagami, 2020).

Local initiatives have so far been stifled in Japan, but the widespread opposition to nuclear power and rising municipal involvement in energy generation and distribution could prevent further contraction.

6.6.4.2.1 Local-national interactions in energy transitions

The current global climate calamity drives home the importance of creating policies that 'stick' by creating positive feedbacks that lead to route dependencies (Jordan & Matt, 2014; Levin et al., 2012). Academics in several related fields, such as innovation studies, public policy

analysis, and sociotechnical transitions, have emphasised the significance of the politics of the energy transition for this task (Cherp et al., 2017; Levin et al., 2012; Meadowcroft, 2009).

This special issue adds to the discussion by providing a framework for understanding the politics of opposition to energy transitions based on theories of institutional change. The ability of firmly established incumbents to provide unfavourable feedback that prevents or undoes changes in national policy has previously been extensively studied. Exogenous occurrences that provide opportunities for repositioning may help these actors (Stefes, 2016). Less is known about how local players participate in these processes (Caprio et al., 2003). This research examines the trajectory of energy changes in the power sector using empirical data to show the effects of local initiatives.

Many studies start from the premise that policy is the main force behind innovation. They have the propensity to "conceptualize community actors as the recipients of policy choices, focusing on elements that encourage or restrict local acceptance" (Jordan & Matt, 2014; Maruyama et al., 2007; Musall & Kuik, 2011). Weinstead emphasises politics as the main factor. Instead, academics place a strong emphasis on politics as the main force behind grassroots energy activism, which catalysed the initial enactment of laws encouraging RE in Germany and Japan.

The economic and demographic benefits of investing in RE are frequently first noticed by local communities (Musall & Kuik, 2011). As a result, they play a significant role in creating the 'socio-political space' necessary for the development of RE technology (Lauber and Jacobsson, 2016:148). As a result, they are essential for stabilising a nation's energy transition and preventing the rollback of low-carbon measures. According to Rosenbloom et al. (2019), stabilisation necessitates integrating the transition into society, including establishing a beneficial 'ecosystem' of public and private organisations.

6.6.4.3 Denmark

Denmark exemplifies effective RE implementation with its commitment to wind power. The country promotes a decentralised approach, engaging local governments to take ownership of renewable projects and reap economic benefits. Through joint ventures with private companies, communities possess a stake in projects and distribute profits for sustainable development initiatives. Since the middle of the 1990s, there has been a greater focus on the importance of local governments and municipalities in the development and implementation of sustainability policies and initiatives on a global scale.

Initiatives aimed at improving the capacity of cities and municipalities to become more active political participants have been sparked by global environmental challenges. In this context, several studies have concentrated on transnational networks between local authorities and the (new) forms, scales, and tiers of governance that these networks may entail (Betsill &

Bulkeley, 2004). The conceptions of ‘global’, ‘national’, and ‘local’ environmental politics as distinct and well-defined entities may be challenged by these new forms of climate governance, among other things (Betsill & Bulkeley, 2004).

A growing number of studies examine the specific scope, opportunities, and constraints faced by local authorities in the planning and implementation of energy and climate policy (Aall, 2011; Baker & Eckerberg, 2007; Burch, 2010). The use of technology at the local level is the subject of a third line of related research (Wessberg, 2002).

The impact of local, contextual elements on the results of certain initiatives is one of the major problems in this research. Most of the research in these two latter disciplines points to a relationship between the local and the national levels, where the former frequently aids local action while the latter is also blamed for limiting the options available to local authorities. Several of the studies have identified an ‘appropriate dose’ of state engagement as a requirement for effective local action, such as long-term strategies, precise instructions, and financial options (Baker & Eckerberg, 2007).

While a growing number of municipalities are exploring and developing their roles as authorities on energy and climate policy, it is also critical to comprehend and investigate the state’s potentially new position concerning these local actions. Such a viewpoint necessitates an integrated assessment of the transition of central and local energy and climate planning There are worries that the growing number of well-intentioned local climate and energy plans in Denmark may lead to too many different and uncoordinated ways. Most of the time, it is still unclear how municipal efforts relate to and impact broader national commitments, as well as which ideas might be compatible with the current institutional framework (Wiegand, 2011).

The primary goal of this study is to determine how well the scope of Danish municipal energy plans corresponds to the goals and benchmarks of the country’s 100% RE strategy. The secondary goal is to describe the general relationship between local and central energy planning. The ongoing transformation of the Danish energy system is described in the previous section to substantiate the notion that local actors, such as municipalities, must be involved in energy planning because of an increasing quantity of decentralised energy production. Then, recommendations are made from a national perspective on how to keep moving the energy system toward complete fossil fuel independence.

Consequently, when it comes to establishing RE systems at the local government level, Denmark has been a pioneer. Their accomplishments can be attributed to a mix of regulations and rewards. The FIT is one such measure that offers producers of RE set rates and long-term contracts. The number of wind energy installations nationwide has increased as a result of this program. Furthermore, Danish local governments have promoted the growth of RE

projects by using their zoning and planning authority. For project approvals, they have established streamlined procedures and chosen ideal locations for wind farms.

Denmark has effectively mainstreamed RE systems inside its local government sector by utilising these laws and incentives. When it comes to regional best practices, California in the United States is notable for its challenging clean energy objectives. The local government sector is essential in this transition, which the state has established as its goal to complete by 2045. California has established community choice aggregation (CCA) initiatives as one of its main strategies. Local governments have more control and flexibility in procuring RE because of CCAs, which enable them to purchase electricity on behalf of their citizens.

As a result of greater competition among energy suppliers and the quick deployment of RE systems within the local government sector, consumers are now paying less for electricity. Japan has made notable progress in the Asia-Pacific area in establishing RE systems within its local government sector. After the Fukushima nuclear accident in 2011, the nation turned its attention to decentralised power generation and renewable energy.

6.6.4.4 Nordic countries

The Nordic countries, including Norway, Sweden, Finland, and Iceland, have focused on the development of clean energy resources as a regional solution. Cooperation among local governments through energy networks and collaborative initiatives ensures knowledge-sharing, expertise exchange, and joint investments in RE infrastructure. Furthermore, the establishment of joint regulatory frameworks and local energy markets facilitates efficient regional coordination.

6.6.4.5 California, United States

California's local government sector is renowned for its robust implementation of renewable energy. The state offers incentives, tax credits, and grants to encourage local governments to adopt renewable sources, fostering innovation and investment. The success of California's Renewable Portfolio Standard (RPS) has urged other states to follow suit, setting measurable targets for RE uptake.

Already, the majority of the oil used in California is imported from other nations. Supporting the state's current domestic oil and natural gas production is crucial for several reasons, among which limiting California's ability to continue producing the energy it requires would raise the state's oil imports, raise gas prices, and put the state at serious risk of energy supply shortages.

Local oil and gas production in California is fuelled by 50,000 Californians and produces $1.5 billion in state and local taxes for public safety, social services, and education. Maintaining

local production in California supports essential services, safeguards jobs, and reduces reliance on more expensive imported oil and the unstable foreign nations that supply it (Carlifonians Energy Independance, 2024).

In California, oil and natural gas extraction are subject to the strictest environmental regulations on the entire globe. Instead of increasing reliance on expensive foreign oil produced in nations without the same environmental, labour, and human rights standards, the necessary oil and natural gas Californians need should be produced locally and sustainably in transitioning to a cleaner energy economy (Carlifonians Energy Independance, 2024).

6.6.5 The South African Development Community (SADC) best practices

As the world faces the pressing challenges of climate change, transitioning towards RE systems has become an imperative for sustainable development. SADC nations have recognised the importance of implementing RE systems in their local governments.

6.6.5.1 Policy framework and regulatory environment

For local governments to successfully integrate RE systems, effective policy frameworks and regulatory environments that are conducive to the adoption of RE systems are essential for their successful deployment. Through the implementation of FIT, tax credits, and regulatory simplifications, SADC countries such as South Africa, Tanzania, Mauritius and Namibia. South Africa implemented the REIPPP program, which has drawn investments from the private sector and encouraged the expansion of RE projects. Tanzania is one of the leading countries that has established policies to promote the coexistence of IPPs with the Tanzania Electricity Supply Company (TANESCO) (Jadhav et al., 2017). Feed-in tariff policies to promote RE power distribution have been established in South Africa, Namibia and Mauritius. These policy frameworks are effective tools that help local governments to promote RE projects.

6.6.5.2 Public-private partnerships:

The successful deployment of RE systems in Africa requires effective collaboration between communities, private sector stakeholders, and local governments. This cooperation makes it easier to share the knowledge, materials, and funding needed to carry out projects. The importance of PPPs is illustrated in various SADC countries. Zambia implemented their first solar energy project in 2019 after establishing coherent policies to boost investor confidence. The Scaling Solar project, which targeted the generation of 600MW of power, was successfully implemented. Its success was attributed to the development of a coherent and transparent process that assigned the role of the public sector, private sector, and financial institutions (Stritzke, 2018).

A 4.5 MW solar PV station was commissioned in Namibia by a French private company, InnoSun, which was appointed as an independent power producer. The installation has more than 30,000 solar panels spanning 15 hectares of land. The project cost $10.79 million, and the funding was provided by the Development Bank of Namibia and InnoSun (Jadhav et al., 2017).

6.6.5.3 Community engagement and Local Ownership

One important best practice seen in African nations is involving the local community in the decision-making process and encouraging local ownership of RE projects. A Zambian case study conducted by (Makai & Chowdhury, 2017) demonstrates the successful implementation of solar energy stations and solar home systems within a school setting. However, the project encountered a land ownership crisis. Initially planned to be constructed adjacent to the community school building, complications arose when the school was donated, the project lost the land and could not succeed. Nevertheless, the Ward development councillor and the community collaborated to secure a separate plot for the project's development.

6.6.5.4 Capacity building

To empower local government officials and communities and ensure the successful implementation of RE projects, capacity-building programs and technology transfer are essential. SADC has fostered partnerships and facilitated knowledge-sharing platforms, allowing local governments to learn from neighbouring countries and technological leaders.

The SOLTRAIN project was initiated by seven research institutes and universities from Zimbabwe, South Africa, Botswana, Lesotho, Mozambique, Lesotho, Namibia and Austria in conjunction with local solar companies. By 2019, the project trained about 3,000 people in over 110 training courses, and lessons that had been learnt were implemented by local companies in over 326 demonstration projects (Weiss et al., 2019). This approach fosters local ownership and long-term sustainability of RE systems, contributing to local economic development.

6.6.6 Lessons for South African Local Government

6.6.6.1 Community-Based Power

Projects for community-based power projects first appeared in Japan in the early 2000s and were inspired by regional initiatives in Germany and Denmark. They are defined by local ownership and control, much like German cooperatives. These projects frequently rely on municipal assistance as well as local power developers to enable effective distribution and transmission. One city that has backed citizen-owned power plants as a means of economic revival is Miyama City.

In 2015, the city created Miyama Smart Energy, a regional energy provider styled after German municipal utilities. Miyama Smart Energy sells RE produced locally and offers extra social and infrastructure benefits to participating inhabitants. These initiatives differ from city programs supported by the federal government in that they place more focus on independently owned, locally produced, and locally consumed energy. Over 180 community power projects were formed across the whole country in the five-year plan, mostly based on solar and wind energy (Koshiba, 2008).

6.6.6.2 Transition Towns

Another lesson to be learnt from the implementation of RE is the use of Transition Towns (TT). In 2005, the idea of using the permaculture concept for community rejuvenation gave rise to the global movement known as TT. The Fukushima disaster aided in the TT movement's mobilisation by bringing attention to the advantages of energy localisation and sovereignty (Otsuki, 2016). In that they seek little acknowledgement from the federal government, TT operate differently from various other types of local participation.

According to an energy activist in Fujino, Japan's first TT, the key impetus was not big energy but rather that individuals were able to generate energy themselves. The town's use of the 'Yorozuya' local currency to encourage community members' networking serves to further this notion of autarky (self-sufficiency). Thus, TT differ from community power projects in that they place more emphasis on fostering a sustainable community culture than formalising local authority over energy generation and consumption.

6.6.6.3 Eco-Model Cities

The implementation of the Eco-Model City (EMC) program is another lesson for the South African local government, which was established by the Japanese government in 2008. It highlights cities that have led the way in sustainable development and low-carbon living, with the aim of market leadership and societal innovation. Under this program, 13 communities are now receiving financial assistance to meet their RE goals. One is Yusuhara, a tiny settlement on the island of Kyushu. Forests encompass more than 91% of its surface. Yusuhara combats the challenge of unemployment and population decline by utilising its natural resources.

The municipality has put into place the Woody Biomass Community Circulation Model Project, a cogeneration endeavour akin to that of St. Peter in Germany that has assisted in reviving the regional forestry industry while producing heat and energy.

Eco-Model Cities have placed energy independence and community revitalisation as their primary objectives in addition to environmental sustainability, aligning themselves with the Japanese government's strategy for energy sovereignty (Yusuhara; "FutureCity" Initiative,

2016). EMCs are distinct from community power projects in that they rely on funding from the federal government.

6.6.6.4 Partnerships for Sustainability and Disaster Prevention

As a result of the backlash against its neglect of public safety following Fukushima, the government's focus has shifted to supporting distributed RE for catastrophe resilience and national security. To maximise the distribution and effectiveness of various types of RE resources, 'smart communities', some of which were directly damaged by the Fukushima tragedy, work with commercial partners and national government agencies, including METI. In these partnerships, corporate players play a significant role, collaborating with smart communities to supply energy infrastructure expertise and technological advancement (microgrid technology).

METI chose eight municipalities in 2015 to take part in smart city initiatives. The advantages of regional Community energy initiatives in Japan, like those in Germany, benefited their members in a variety of ways. The advantages of RE for local economies aid in reversing unfavourable population shifts. Local economies have been strengthened through community power initiatives that entail collaboration with nearby companies. Communities like Yusuhara have used natural resources to boost employment and entice temporary and long-term residents. An official from Yusuhara claims that these initiatives have increased community understanding of climate and sustainability issues through demonstrable progress. Building social capital through energy independence is a stated goal for Transition Towns like Fujino.

Other communities have benefited from social capital spillover effects that give people a sense of empowerment to take matters into their own hands (Maruyama et al., 2007), even though they initially got involved in local RE projects primarily for energy self-sufficiency and economic disaster recovery. Technology frequently has unintended side effects. At TT Fujino, educational PV conventions and workshops are hosted annually for residents.

Miyama Smart Energy developed an integrated Home Energy Management System (HEMS) for the city's growing elderly population to track energy usage and provide additional social services like grocery shopping and health check-ups (Hager & Hamagami, 2020). As a result, a civic society that had previously unquestioningly supported the corporatist, government-industry status quo has experienced enormous upheavals of community involvement in RE initiatives.

6.7 Summary

Many authors thought that laws for RE may be utilised to remove barriers to the sector's growth, enhancing its capacity to compete with conventional energy. Some of the most

significant RE schemes include tax incentives, loans, FIT, and RPSs. Tax incentives were crucial in encouraging customers, companies, and RE investors to migrate from conventional to RE sources. About 100 countries also use loans as a supplementary tactic to aid in the expansion of renewable energy.

Academics claim that the FIT and RPS are the two RE policies that are most frequently utilised to encourage the development of renewable energy. Germany has excelled at promoting the use of RE sources to generate electricity. Studies have looked at how FIT rules affect the deployment of RE using a variety of models and countries. This investigation found positive benefits of the spread of RE.

The expansion of RE has several effects, including those on welfare, CO_2 emissions, job creation, economic growth, and fuel imports, according to a review of the scientific literature. Consuming renewable resources helps different countries' economies expand. However, some countries, such as Iran and Nigeria, may have negative repercussions from adopting RE due to the absence of an institutional framework and policies implemented to support it. Numerous studies have demonstrated that the usage of RE sources generates a significant number of direct jobs in several different countries.

Contrary findings exist regarding renewable energy's impact on employment, potentially displacing jobs from other sectors. While some studies confirm emission reductions with renewable energy adoption, conflicting evidence exists. Increased renewable energy usage does not consistently lead to emission reduction despite prevalent research suggesting otherwise. However, numerous studies highlight renewable energy's significant benefits, including enhancing public health and improving the well-being of disadvantaged populations.

7 CHALLENGES THE SOUTH AFRICAN LOCAL GOVERNMENT CAN FACE IN PROMOTING RENEWABLE ENERGY SYSTEMS

7.1 Introduction

Decarbonisation of the energy sector is associated with various advantages such as climate change mitigation, protection of people from health-hazardous energy streams such as paraffin and candles and its contribution to energy mixing in the alleviation of energy poverty (DMRE, 2019). Implementation of RE in local municipalities is likely to face challenges ranging from technical, financial, social and regulatory issues. The major challenge in committing to or successfully transitioning to RE energy lies within several socio-political dimensions, which should be carefully addressed (Todd & McCauley, 2021a). According to SALGA (2021), much research has been done on RE, and other strategies and policies have been set up within the South African context. However, implementation remains a major challenge, impeding the transition to green energy at the municipal level. In cognisance of such factors and how these are likely to impact local municipalities in rolling out RE, this section presents and describes major challenges likely to be faced by local municipalities in implementing RE, as summarised in Table 3.

Table 2: Major potential challenges that might be faced by the local municipalities in transitioning to RE

Challenge	Reference
Policy and political barriers	Todd and McCauley (2021a); Apfel et al. (2021); Nel (2015); Averchenkova et al. (2019)
Limited financial resources	Todd and McCauley (2021a); Madumo (2015);
Skills and expertise	Nel (2015); WWF (2015)
Access to finance	Ebhota and Tabakov (2021); Mirzania et al. (2023); DMRE (2019)
Community resistance	Nel (2015); Yaqoot et al. (2016); Rediske et al. (2021).
Land use and space limitations	eThekwini municipality (2020); Weinand et al. (2019)
Infrastructure, Intermittence, storage and grid constraints	Madumo (2015); Aliyu et al. (2018)
Bureaucracy	Todd and McCauley (2021a); Nel (2015)

Resource dependency	Apfel et al. (2021)
Lack of public awareness	Nel (2015)

7.1.1 Policy barriers

Key strategies have been put in place to support RE in South Africa, but the implementation process is lagging due to policy misalignment. Averchenkova et al. (2019) explain that a lack of policy coherence amongst climate change goals, objectives set for other strategic goals and policy documents that determine the pathway of the goals is one of the challenges. According to Yaqoot et al. (2016), global inconsistencies in policies are attributed to the bias on fossils and nuclear over renewables. The same concern has been raised in South Africa, where the alignment of the draft IRP with the NDP and other industrial policies, such as the Nuclear Policy (2008), were queried. However, after the South African DMRE agreed that there was no contradiction between the policies, they responded that it is still not clear whether nuclear will be needed before 2030 (DMRE, 2019). In a move to address policy misalignment, Herbst and Lalk (2015) suggest that the government should synergise projects tailored around achieving the same goals in alignment with NDPs, and the same was suggested by Mirzania et al. (2023).

Lack of clarity in the legal and regulatory framework to guide the implementation of RE has been identified as another policy barrier. Yaqoot et al. (2016) did a case study using the decentralised renewable energy system (DRES). They found that city planners may face challenges with the technology due to the lack of established procedures for siting and installation. A lack of common ground in governmental departments to support RE was also reported by Jogiat (2014). This challenge is due to a lack of communication and interaction between the government and the private sector – the government works on policy improvements, while the private sector focuses on improving compliance (WWF, 2015). Some interventions, such as the REIPPPP, were supposed to benefit local communities with employment creation on the one hand. However, on the other hand, this made it difficult to outsource scarce skills from foreign countries (Mirzania et al., 2023). Unclear policies to provide opportunities for scarce foreign skills have negative implications on investor confidence. Therefore, clarity and commitment to apply equity policies are needed (Adewumi, 2022) to increase investor confidence in the sector while meeting the core business of protecting the environment and improving livelihoods (Ali et al., 2023).

Maladministration is another challenge whereby unaccountable governmental officials get away with corruption scot-free. Sometimes, there is no transparency in the decision-making process due to top management's political and personal interests and lack of literacy and consciousness about environmental protection (Li et al., 2023; Mirzania et al., 2023; Todd &

McCauley, 2021a). Policies that provide local governments with clarity on decision-making in implementing RE could be improved through research and development (eThekwini municipality, 2020). Nel (2015) suggests that policies focusing on the management of an interface between private and public partners by building an accord with transparency, stakeholder management, effective and accountable administration, and better decision-making are needed.

Liberating municipalities as independent entities that can directly purchase energy from the private sector is one of the challenges and a policy barrier. A global review by Apfel et al. (2021) addresses the policy and governance issue in RE, finding that the government is regarded as an autonomous actor. In South Africa, Eskom is the largest monopoly state-owned entity operating South African energy services, and it dominates the energy market (Nel, 2015). A case study done by Todd and McCauley (2021a) in Cape Town shows that municipalities do not have the power to decide on implementing energy technologies of their choice. There was an incident when the Cape Town municipality had to take the federal government to court to get permission to produce electricity at full scale from IPPs. In the same study, during a separate interview, the authors gave an example of the OR Tambo International Airport wanting to produce 30MW of electricity from renewables. However, the government brought the idea to a halt. Subsequently, the recent draft SAREM has shown the relaxation of such policies, whereby municipalities can purchase from SSEG (DMRE et al., 2023).

The lack of policy support for RE has a great impact on the transition process if not addressed well. A constraint feasibility ranking done by Mirzania et al. (2023) shows that the lack of policy support for renewables scored >60% frequency based on the coding of the data of the interviews they conducted. The lack of transparency and coherence of policies regarding the REIPPPP has affected the transition in the energy sector.

Despite constraints in the liberation of local municipalities to decide on purchasing energy from private producers, the policies have significantly changed, allowing them to purchase more energy for their grids (DMRE et al., 2023). Municipalities can purchase power from SSEG. To date, certain municipalities have initiated SSEG installations, while others have implemented application procedures for SSEG seeking connection to municipal grids. Additionally, in some instances, NERSA-approved SSEG tariffs have been secured, enabling compensation for customers (SALGA, 2021).

7.1.2 Financial constraints

Most local municipalities lack the financial capacity to roll out RE. As a result, they are unable to repair the grid infrastructure, and Eskom faces the same problem. Madumo (2015)1304)

shows that most South African municipalities are unable to sustain themselves financially, and they cannot even deliver constant and uninterrupted services. The incapability of municipalities to finance infrastructure and human resources for RE has also been reported by Mbazima et al. (2022) concerning LFGE. The same was also reported by Aliyu et al. (2018) within the context of Pakistan. The finance issue got mixed reactions from participants in a study done by Todd and McCauley (2021a). Although the authors believe that finance is a barrier, some interviewed respondents argued that it is not. They based their stance on the fact that the REIPPPP comes from South African pension funds, which are known to be financially strong. PPPs can counteract financial challenges to increase municipal technical and financial capacity to operate RE at the utility.

Infrastructural damage, electricity theft from informal settlements and poor credit controls are some of the major reasons that contribute to poor municipal financial operations. These factors also affect the operations of Eskom, as the local municipalities are not able to settle their power debt. According to DMRE (2019), the municipal debt for bulk purchases of electricity from Eskom stood at R31.5 billion in 2018, and the figure is projected to rise. COGTA was identified as an entity that can support municipalities in this regard.

Currently, there are limited PPPs to support RE within local municipalities, and this is attributed to high risks on investments. Jogiat (2014) highlights that the absence of PPPs to support waste-to-energy initiatives in the uMgungundlovu District municipality, where livestock and animal waste are abundant, contributed to the slow implementation of proposed energy generation projects. This same was reported in the waste-to-energy projects by Mbazima et al. (2022):1301). Aliyu et al. (2018) brought up the issue of economies of scale, where the mismatch of interests between the government (local municipality) and investors plays a role. The local municipality is concerned about energy security regardless of production scale, while the private entity needs large-scale, profitable production.

The government may play a role in improving policies to finance municipalities. For example, Naicker and Thopil (2019) point out that governments may work in partnership with financing organisations to incentivise lower lending rates for technologies such as biomass energy.

7.1.3 Community resistance

Renewable energy is still emerging and is likely to encounter resistance due to concerns about willingness to pay premium prices. Yaqoot et al. (2016) report that preference for conventional energy sources and consumer inertia create behavioural barriers impeding the uptake of RE. According to Nel (2015), there is general community resistance to higher energy prices, being perceived as a threat to economic development and poverty alleviation as per the expected

goals of rolling out RE. The energy transition should provide a balance between environmental protection and potential job losses from conventional energy value chains. According to Cock (2019) three social spaces of energy transition needing attention to prevent social injustices and resistance include mining-affected communities that are concerned about the dispossession of lands, environmental justice organisations concerned with climate change mitigation, and labour unions concerned about employment security and socio-economic issues. Trade unions have been reported to play a role in resisting the RE as they fear job losses across the coal value chains. There was an incident when the National Union for Metalworkers of South Africa (NUMSA) took the government to court in an attempt to stop the signing of the power purchasing agreement but they lost the case (Mirzania et al., 2023).

Some people are sceptical about having RE technologies in or close to their backyards because they lack technological awareness. According to Rediske et al. (2021), people have positive perceptions of RE as long as it is not installed in their homesteads. The authors further elaborated that if the implemented RE projects fail, there is the likelihood of protests, community divisions and damaged relationships with authorities. Public acceptance increases when people benefit from incentives during construction and after construction (Rediske et al., 2021). Thus, involving the community by sourcing locally available resources, including labour, is vital for early acceptance of RE. The same applies to the idea of RE policies such as REIPPPP, which aim to empower and contribute to community development (Davies et al., 2018).

Resistance is not solely limited to community members but local municipalities as well. The municipality plays a role in electricity generation, which accounts for about a third of their income generation. SALGA (2021) highlights that certain local municipalities have a general resistance to SSEG systems because of their potential impact on municipal revenue and their electricity grid. This scenario has been attributed to the slow approval of SSEG policies by local governments. A recent news report indicated the concern of South Africa's Public Enterprises Minister regarding the rapid increase in private small-scale solar energy generation, which has surged by 350%. This surge has resulted in over R300 million in potential revenue losses for the Buffalo City Municipality in the Eastern Cape (Ndenze, 2023). Therefore, it is crucial to establish proper structures that eliminate barriers hindering Public-Private Partnerships (PPPs) and facilitate the contribution of SSEG to the local municipality grid, similar to the setup of the South African Renewable Energy Masterplan (SAREM).

7.1.4 Skill and expertise

The lack of skills within local municipalities to drive the strategic direction of investing towards RE is one of the challenges. This factor could be attributed to a lack of governmental interest

in transitioning to RE at the expense of conventional coal-based energy. According to interviews done by Todd and McCauley (2021a), the government does not consult, lacks strategic direction in RE and is sometimes comprised of weak institutions. Corruption within the government and competing interests also play a significant role. For example, Eskom – a government-owned power company –depends on fossil fuels for electricity generation because of its abundance in South Africa. Therefore, Eskom is not likely to invest in RE if it impacts its revenue. In addition to misgovernance, managerial incompetence includes corruption like bid rigging, top management lack of environmental awareness (fossils vs green energy), political interests, lack of moderating role on financial flows (Ali et al., 2023), lack of enforcing existing policies, mismanagement of funds, insufficient collaboration with the international community and the absence of the rule of law (Aliyu et al., 2018).

However, Averchenkova et al. (2019) highlight that such challenges are acute at the municipal level. Interviewees from local municipalities stressed that the technical capacity shortage to drive climate change is greater for local municipalities since they do not have dedicated posts for climate change officers (Averchenkova et al., 2019). They provided an example of a traffic cop who also works as an environmental officer at the same.

Some metropolitan municipalities such as eThekwini and Cape Town are involved in international RE forums such as C40. They have an opportunity to acquire adequate international experience and diffuse it to other municipalities via their fora, which include over 200 local municipalities (Todd & McCauley, 2021a). However, this is not the case. Lack of skills in risk management practices, especially in the public sector, is one of the hindrances despite the existence of existing policies (Nel, 2015).

Lack of stakeholder engagement skills to leverage funding through partnerships with foreign investors is one of the challenges that might be faced. Increasing interaction between national and foreign capital by increasing the developmental effect of foreign investment may improve municipal service delivery capacity (Madumo, 2015). This strategy will need foreign expertise to minimise risks. In a study done by Mirzania et al. (2023), 80% of the interviewed people believed that foreign investments bring in new expertise in the skills-scarce country. According to Aliyu et al. (2018), external assistance in state-of-the-art technologies may minimise investment risks. Some countries, such as Egypt, have set up policies to attract foreign investors to meet their targets in RE (Aliyu et al., 2018). Currently, South Africa depends on foreign direct investments (FDI) in the nationwide construction of solar power panels (Mirzania et al., 2023; Todd & McCauley, 2021a). However, this has instilled additional socio-economic challenges, such as competition between local investors and foreign investors for both labour and productivity.

Most RE technologies are new and require technical expertise for installation and maintenance. Mungodla et al. (2018) highlight the lack of highly skilled human resources to design, implement and monitor biogas plants as some of the challenges. Limited knowledge of job creation and the potential for skills development in the biogas industry are some of the skills that are lacking. Therefore, policies on improving knowledge transfer and better technological maintenance (Naicker & Thopil, 2019) and strategies to develop and retain skilled personnel are required (Mungodla et al., 2018).

7.1.5 Bureaucracy

Some of the procedures for registering IPPs and acquiring operational licenses are lengthy and involve much paperwork, slowing down the success of RE implementation. For example, the REIPPP procurement process is very tedious, and some small-scale local private entrepreneurs may not meet the minimum requirements (Mbazima et al., 2022; Todd & McCauley, 2021a). This obstacle impedes the involvement of private investors by creating uncertainty in the projects (Nel, 2015)60). Less bureaucratic processes give international investors a conducive environment to invest (Akinbami et al., 2021). The South African government established policies such as the Clean Development Mechanism (CDM) to spearhead the utilisation and integration of RE (Mbazima et al., 2022). However, the CDM loan application process is stringent and involves many processes, which slows down the process to support PPPs. One of the reasons for these bureaucratic processes is the use of a top-bottom approach where communities and stakeholders are not consulted in policymaking (Nel, 2015). Thus, policy reviews are needed to optimise the government procurement process.

7.1.6 Attitudes and perceptions

Local municipalities may have a negative attitude towards adopting RE in their jurisdiction area. One of the reasons might be hesitation to adopt new ways (also termed fear of the unknown) (Todd & McCauley, 2021a). According to SALGA (2021), 55 local municipalities are reluctant to transition to new energy forms as they fear it will impact their revenue and the local grid. Furthermore, before local municipalities can engage in RE, they must prioritise addressing other service delivery challenges which they are struggling to provide. However, RE is being recognised as an option to solve some of the municipal energy challenges. SALGA (2021), in conjunction with various stakeholders, including scientific organisations, has developed certain strategies to integrate RE as part of daily service delivery priorities where feasible.

The RE sector is still grey and requires more research to understand several issues related to social dynamics around its implementation. Apfel et al. (2021) point out that research on social issues is needed to understand the dynamics and drivers affecting the adoption, acceptance and rejection of RE. For example, the techno-economic aspects of biogas production are not accurate due to limitations in waste stream data (Jogiat, 2014). In addition to lessons learnt from uMgungundlovu district municipality and a solar case study in Pakistan, it can be deduced that there is no information on community awareness, market dynamics, sustainable value chains, financial analysis, stimulation of stakeholder participation, financial planning and enabling policy environment (Ali et al., 2023; Jogiat, 2014; Mbazima et al., 2022).

Identified research gaps are complex and limit private investors. Therefore, transformative research involving local communities, private sectors, academia, regulators and local municipalities in co-identifying context-specific issues followed by co-testing and co-improvement of scalable RE technologies is needed. This aspect has been mentioned by Ebhota and Tabakov (2021)1243), who provide a European case study as an example. eThekwini municipality (2020):12) mentions research, development and policy adoption as major tools to spearhead the implementation of RE. Another example of research requirements is a case study by Kassem et al. (2023) concerning the applicability of solar PV for household electricity within the Botswana context.

The introduction of new energy technology will trigger some social perception issues. According to Amigun et al. (2011), human attitudes are variable, dynamic and sometimes contradictory, meaning that it is not always the case that people are likely to adopt a certain technology. A positive attitude toward RE depends on the awareness level of households (Munien, 2016). Awareness campaigns are crucial to trigger the adoption rate of any technology (Nel, 2015). Although RE is less likely to receive resistance from communities because of the perceived potential in solving existing energy crises (DMRE, 2013), challenges arise when the communities are approached wrongly. A study by Mirzania et al. (2023) shows that if the communities are not engaged from the beginning and provided adequate awareness of the project coming into their communities, they are likely to cause problems. The authors provide an example where projects are just imposed on communities while exaggerating expected benefits such as jobs and development. Resistance from people within the fossil energy sector is another challenge, as people are scared to lose their jobs and are expected to reskill in the RE sector. The perceived impact on job creation might not be sustainable in the long run. For example, closing a mine that has been a source of livelihood to certain people in favour of a solar construction plant, which might take less than 18 months to construct. In this regard, long-term plans to deal with job losses in pursuit of RE are needed.

7.1.7 Land and space constraints

Finding suitable land for RE should consider social, environmental and economic issues such as the displacement of existing communities, wildlife and convenience for wheeling. One of the challenges is that a suitable site with potentially high wind or solar yields might not be ideal due to other factors. Some municipalities, such as eThekwini, are mainly comprised of residential and industrial areas, which makes it difficult to install large-scale wind or solar farms (eThekwini municipality, 2020). Some technologies, such as biogas production, may rely on agricultural land. In such cases, there might be competition for food production and energy generation (Weinand et al., 2019). The establishment of large-scale hydro-energy dams implies displacing people from their residential areas (Naicker & Thopil, 2019). Wind turbines are associated with noise pollution and the death of wildlife birds. The South African National Environmental Management Act requires an EIA to be done before implementation. The idea is to provide RE while protecting environmental integrity. Getting the right bioresource information for easy planning might be a barrier (Yaqoot et al., 2016). The spatial dynamics in RE create areas of high tension called ‘friction zones’. Some communities are likely to benefit from RE implementation through employment creation within the respective areas, which might create resentment among communities staying in non-suitable regions (Mirzania et al., 2023).

7.1.8 Infrastructure, grid constraints and energy storage

Renewable energy production is intermittent, requiring energy storage during peak periods and wheeling generated energy into the municipal grid. According to Aliyu et al. (2018), current electricity transmission is characterised by alternating current (AC), which allows for long-distance energy transportation. However, requirements to balance RE due to intermittent supply is a very big challenge (DMRE, 2019). However, this was eliminated as not being an issue because the IRP has considered such aspects. South Africa does not have the adequate infrastructure to accommodate energy generated from IPPs, and SSEG is needed. Currently, Eskom – the electricity company that manages electricity distribution to the national grid – is facing financial constraints and is unable to maintain existing infrastructure (Eskom, 2019). As a result, they are losing potential opportunities to export power to other countries where there are market opportunities. The DMRE (2019) suggests that transmission infrastructure is needed to unlock continental opportunities, which is possible with proper regional integration through increased collaboration and alignment of policies. Local municipalities will need to consider energy storage for microgrids in rural areas where connection to the main grid is a challenge. According to SALGA (2021), such a consideration comes with extra capital costs attached, which needs careful consideration. According to eThekwini municipality (2020), it is

a municipal mandate to install storage facilities that can be integrated into their grid in a way that minimises the need for grid expansion. Another critical consideration is the operation and maintenance of energy storage facilities, demanding highly technical and specialised skills to minimise replacements. Additionally, legislation regarding battery energy is not well-developed in South Africa (eThekwini municipality, 2020). Consequently, investing in sufficient skills poses a challenge, particularly given the financial constraints faced by municipalities.

7.2 Summary

Local municipalities are poised to encounter numerous challenges during their transition to RE. These challenges encompass policy misalignment, ambiguity in the legal and regulatory framework guiding RE implementation, existing policies favouring fossil-based energy, inadequate policies to attract foreign skills crucial for bolstering investor confidence, and the need for policies to ensure accountability among top management.

Moreover, most local municipalities lack the financial capacity to facilitate RE deployment and repair grid infrastructure. Contributing to Eskom's financial woes, municipalities have defaulted on energy debt payments due to infrastructural damage, electricity theft in informal settlements, and weak credit controls within municipal financial operations.

A shortage of skills within local municipalities poses a significant challenge in steering investment towards RE. Insufficient expertise hampers stakeholder engagement, inhibits the formation of PPPs, and limits the ability to secure funding from external sources. Additionally, the novelty of RE technologies necessitates technical proficiency for installation and maintenance, skills often lacking within local municipalities.

Bureaucratic hurdles further impede progress, discouraging potential investors. Lengthy procedures for registering IPPs and obtaining operational licenses, coupled with extensive paperwork requirements, act as barriers to the successful implementation of RE initiatives.

Social perceptions and attitudes from government, local government, stakeholders and communities are crucial for the success of the RE transition. Some of the community resistance risks are attributed to willingness to pay for premium prices and having the technology as far from the backyard as possible. Some local municipalities generate revenue from fossil-based energies, so they do not want to distort their revenue streams. From the government's point of view, political issues may drive the decision-making process.

The availability of suitable land poses a challenge for RE projects. Often, the most suitable land is linked to other social issues like displacing settlements, competing priorities between

food security and energy security, and social tensions arising from uneven benefits distribution, including noise pollution and environmental impacts such as bird deaths.

Furthermore, integrating RE into national and regional grids presents challenges. Factors like energy storage, stabilisation, and wheeling require additional costs and skilled personnel to manage effectively, adding complexity to the process.

8 EMPIRICAL FINDINGS

8.1 Introduction

This study aimed to investigate the role of the local government sector in promoting RE and the implications on skills development. A rigorous literature review of academic documents and grey literature was done to address the research questions and identify research gaps. Building upon the literature review, a quantitative and qualitative study was conducted to get insight from key informants on the role of local municipalities in adapting to renewable energy, the feasibility of implementing RE in local municipalities, the identification of skills required by the local government sector, understanding the regional and international best practices in implementing sustainable energy systems and challenges that are likely to be faced. The key informants were coded as uMsunduzi local municipality (R1), TIKZN (R2), CSIR (R3), Nelson Mandela (R4), Bhesheni Energy Solutions (R5), Botswana University (R6) and Newcastle local municipality (R7).

8.2 The Role of Local Government in Adapting to Renewable Energy

The role of the local municipality is to create an environment that supports RE adaptation. According to a respondent from Botswana University (R6), local municipalities play a role in the provision of sufficient information to energy producers, facilitating permitting and licensing, providing access to land, and implementing education and awareness training and campaigns. The key informant from uMsundizi municipality (R1) identified the roles of establishing IDPs on renewable energy and creating a conducive climate for RE projects.

8.2.1 Policies and regulations

Local government plays a significant role in developing policies that create an enabling environment for renewable energy. According to a respondent from TIKZN (R2), the local governments are mandated by the Municipal Systems Act (2000) to deliver services such as energy, water and health care. Economic activities that increase economic growth within a municipal jurisdiction create employment opportunities.

> *They have a mandate in terms of our current legislation and constitutional imperatives in the country towards service delivery, and that's in the Municipal Systems Act. But in addition to that end to enable well, you can call it social stability. Economic prosperity in the areas of jurisdiction, and energy security becomes paramount because that leads to job creation. Social harmony and all of those good things. And I think that's as simple as it can be put R2.*

Space for RE can be created if local municipalities set up priorities within their IDPs (R2). According to R1, most municipalities are dealing with various long-standing issues without considering current affairs, such as sustainable energy pathways. They should start exploring RE as an alternative revenue stream, which is achievable if RE is prioritised in the IDPs (R1). For example, some municipalities are allowed to purchase energy directly from Eskom and sell it to domestic users and industry. Although municipalities want to protect their relationship with Eskom, inevitably, due to load-shedding and efforts by industries to look for alternatives to Eskom, local governments are forced to adapt (R1, R2). The City of Cape Town is an example of a city that has been innovative enough in the RE space and is likely to attract independent power producers (R1). Newcastle local municipality (R7) is trying to adopt Cape Town City's RE implementation model and has set up a RE roadmap that is expected to be out by June 2024. They cited that the RE roadmap will allow them to engage with relevant stakeholders and implement a profitable RE plan.

> *That's why we are saying before we can tell the people what we're going to be doing, we need to get our house in order R7.*

Local municipalities should create clear regulations on RE to attract investors. Currently, municipalities are energy insecure while sitting on vast resources that can provide alternative energy forms. R2 gave an example of the Msunduzi local municipality, which produces plenty of organic waste from anaerobic digesters at the New England landfill site. In addition to that, there is animal waste emanating from piggeries and cattle and poultry farming within the uMgungundlovu area. Although these waste streams can potentially be used to generate energy, there are no clear policies to incentivize their implementation. Other examples are the Cape Town and eThekwini municipality landfill gas collection (R2). According to R7, there are over 85 wastewater treatment plants in South Africa that could potentially be used to harness biogas to generate energy that can add to the local grid. However, most wastewater treatment plants WWTPs around the country are not performing well.

> *…How can the government encourage and as I said, it's in terms of at least? To ensure energy security, but secondly, there's a financial benefit as well to households. If households can understand that if they use less electricity, they have to pay for it as part of the electrical tariffs, that becomes a very good compulsion, and there should be policies in place. I'm not aware of any really what I'll call proactive policies to encourage that… R2.*

Municipalities are different in the way they prioritise sustainable development programs and are taking off at different paces. R2 gave an example of a meeting in which the topic of the water-energy nexus was presented to the South African Cities Network in 2014. None of the

municipalities that were present have implemented the idea, but some metropoles are beginning to move towards a sustainable direction (R2). One of the interviewed municipal officials confirmed that they are in the process of implementing RE in their jurisdiction and drafting policies for that (R3). All these challenges are attributed to a lack of clear policies from the government level.

While much discussion revolves around the creation of policies, the crucial issue lies in their implementation and adherence. As highlighted by R7, establishing policies is just the first step; ensuring strict adherence is essential. This necessitates the development of guidelines to incentivise cooperation and ensure compliance among stakeholders.

8.2.2 Incentives

Municipalities should develop strategies to incentivise RE across all the actors in the value chain. One of the significant challenges faced is the presence of policy gaps hindering the promotion of renewable energy. According to R2, privatisation is one of the options being implemented by other countries to establish businesses at economies of scale, which requires large infrastructural investments.

> *That's at the Bizana roadside, so there are opportunities there. As I said, Davao, where you guys are located has opportunities there more rural municipalities. I think it becomes a bit of a challenge, but if, like I said, if policies are there that allow even rural homesteads where they, you know, cow dung, the biomass and methane generation there for point of use application becomes very useful. There is a vacuum of policies and I think how can the government encourage that? R2*

Municipalities may create opportunities for the private sector to recover from large-scale investments. It can be through low taxes and the provision of long-term concessions of not less than ten years and ideally up to 20-30 years (R2). According to R2, such long-term and large-scale investments need strong investments in social management and security to protect them from vandalism and theft and attract investors. The same was reported by R7, where investors submitted proposals to generate electricity on a large scale that was profitable. In return, the local municipality is planning to provide a market for the generated energy, which they will sell to households and other entities. However, R7 further emphasised the plans to sell excess energy to surrounding municipalities, which are incapacitated, to support large-scale generation. From the incentive point of view, R6 gave a perspective on indirectly enhancing or incentivising RE value chains by giving the example of municipal wastewater treatment, allowing energy generators to produce the power they will sell to the

municipality and valorise by-products such as sewage sludge into organic fertilizer and sell to farmers for food security. The municipality may play a role by implementing tax breaks and providing a ground for technological improvement.

8.2.3 Public-private partnerships

The PPPs play a role in supporting local municipalities that are financially constrained in establishing infrastructure for large-scale, profitable energy generation. One of the interviewed municipalities is interested in establishing PPPs with potential small investors who are willing to generate energy at a large scale (R7). The private company is targeting about 100MVA of power instead of 20MVA previously generated from the non-functional derelict Eskom infrastructure. The company has been actively engaging with the Newcastle municipality, and they were offered a contract to generate electricity using biogas. These are not only projects planned by Newcastle municipality; they are looking forward to attracting more investors who will use technologies such as pure purified coal and sulphuric acid, which has been utilised at one generation plant in Colenso and Kilbarchan in Newcastle (R7).

The challenge is that private companies are profit-making business entities concerned with profit-making, which might not agree with the overall municipal mandate to provide affordable energy to all groups. In this regard, a sustainable and fair business model is needed in PPPs (R2). This means that care must be taken when considering the PPPs; they must align with the broader goals of the municipality in terms of sustainable and equitable energy access for all.

> *But one of the ways, I mean, we often talk about public-private partnerships. I think it goes beyond that. I mean, last week I happened to be present at a webinar at the National Business Initiative, the Strategic Water Partners Network, and I think one of the banking houses put up a little model that goes beyond the PPP model, looking at how communities, private sector and local and government can come together. And like I said, it's not just PPP, but it's a collaboration model R2.*

8.2.4 Summary

Building on existing literature and identifying gaps, both quantitative and qualitative studies were conducted to assess the contribution of local municipalities to RE adaptation. The studies aimed to evaluate the presence of policies and incentives supporting RE adaptation.

Key findings from the research indicate that some top managers in certain local municipalities do not prioritise RE as a crucial economic development activity to address the energy crisis.

Consequently, RE may be absent from their IDPs, resulting in a lack of clear policies supporting the implementation of RE activities such as waste-to-energy projects.

PPPs play a significant role in assisting financially constrained local municipalities in establishing infrastructure for large-scale, profitable energy generation. However, the effectiveness of PPPs in ensuring sustainable and equitable energy provision is contingent on their proper implementation.

8.2.5 Recommendations

- Local municipalities should treat RE as an alternative revenue generation option, which should be included in their IDPs.
- Local municipalities should establish clear policies on RE implementation to attract private investors.
- Even if policies are put in place, there must be a way to support their strict implementation and compliance monitoring.
- Policies should be developed through municipal guidelines and by-laws to incentivise the RE value chain by introducing tax credits and breaks, providing markets for independent power generators and promoting other value-addition options such as valorisation of the wastewater treatment sludge into organic fertilisers for agricultural use.
- The national government should put in place policies that ensure that PPPs are implemented following a sustainable model that is profitable to the private sector while providing affordable energy to communities.

8.3 Municipalities' Role in the Field of RE Production

8.3.1 Participation of municipalities in renewable energy

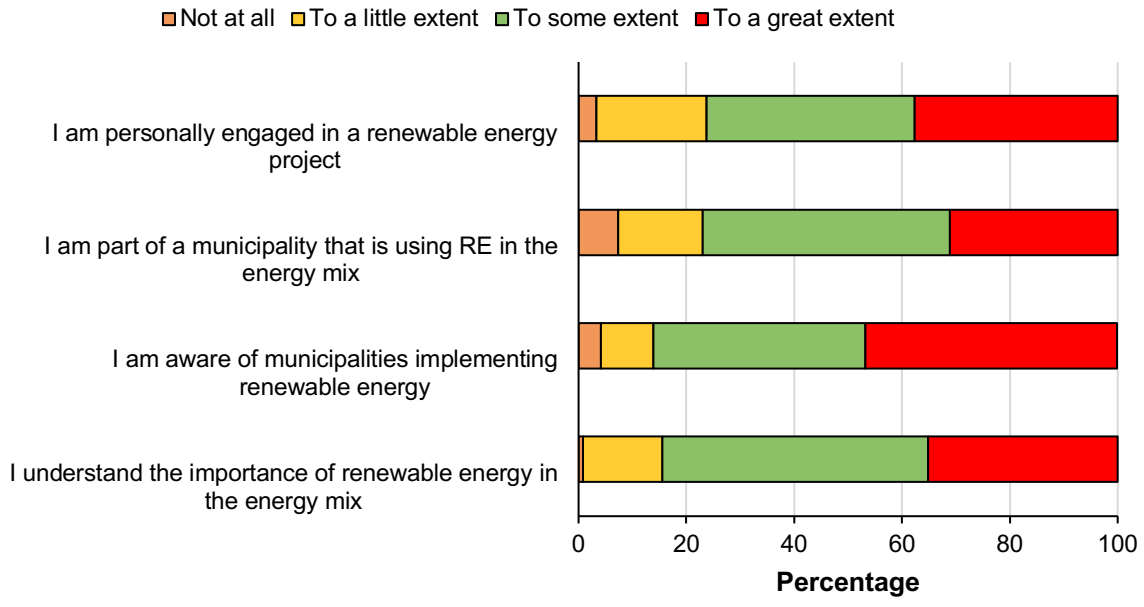
The participation of local municipalities in RE was assessed, and the results are reported in Figure 8.1. The majority of the respondents understand the importance of renewable energy. A few of them (7.4%) are not part of the municipalities that are using renewable energy. Some confirm that they are personally engaged in a RE project to a certain extent. These findings imply that the respondents have a general understanding of renewable energy.

Interviews conducted show that some municipalities are actively participating in RE. R2 mentioned that they had a large-scale solar project operating in the coastlands of South Africa

as early as 2005. The plant was established to integrate RE into the energy mix. This undertaking is not limited to that municipality; some local municipalities are operating very large RE projects generating as large as 20 MW of power. For example, the enterprizeilembe has set up a large-scale (50 ha) hub to support renewable energy in the Isithebe Industrial Estate in Mandeni within the iLembe district. The same applies to the Amazon solar project operating in the Northern Cape Province of South Africa where about 10 MW (28,000 MW hour per year) are expected to be generated. Some renewable energy projects are being put in plan by other municipalities such as eThekwini municipality and Richards Bay. During an interview with the Nelson Mandela Metropolitan Municipality, it was reported that they started RE projects as far back as 2005, and they are doing well (R4). The Newcastle municipality is in the process of implementing RE projects. So far, one project has been pioneered by Eskom, and it is expected to commence within 10-15km of the local municipality boundary (R7).

> *So in so, for instance, Amazon doozy is very far advanced in lembe are doing some very good work. In Ethekwini as well, and then in Richards Bay we've got I think both Richards Bay and Empangeni R1.*

Figure 8.1: Responses on the participation of local municipalities in RE



8.3.2 Benefits brought about by renewable energy

A quantitative study on the benefits of RE was conducted, and the results are shown in Figure 8 28.2. The benefits are socio-political, socio-economic and environmental. Survey results

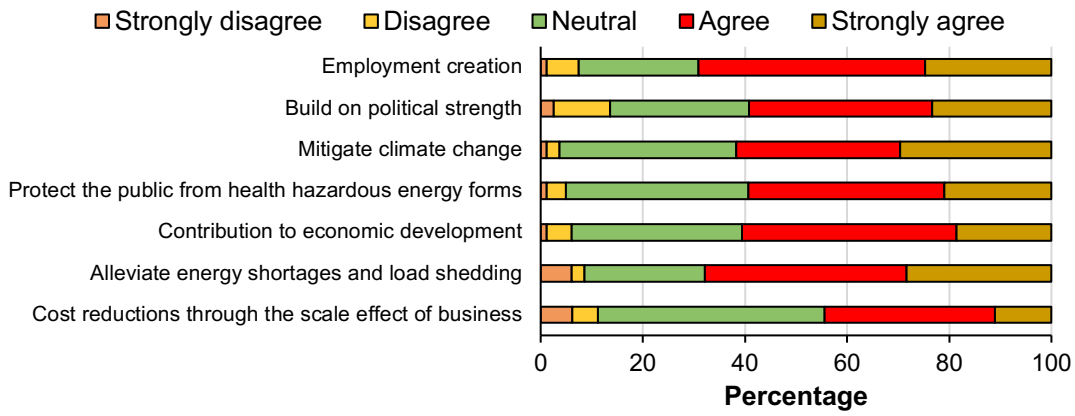
indicate that a majority of respondents (>30%) agree on the benefits of renewable energy (RE), including employment creation, building political influence, mitigating climate change, safeguarding public health from harmful energy sources, fostering economic development, addressing energy shortages and load shedding, as well as reducing costs, thereby positively impacting businesses. A small percentage of respondents (6%) strongly disagreed that RE contributes to cost reduction through the scale of the effect of business and mitigates load-shedding and climate change.

The overall benefits of RE have been reported in the literature and by almost every stakeholder interviewed. From an employment creation point of view, the benefits are dependent on the extent to which value chains are enhanced. Income-generating economic activities across the RE value chain, from manufacturing, generation and wheeling, determine the contribution of different actors, including human resources (DMRE et al., 2023). The same applies to opinions provided by R1, who mentioned that skills such as engineering and data capturing will be needed for the manufacturing and generation stages. Which means anyone involved in those activities will be employed.

Almost every key informant has mentioned climate change. Exploration of RE is one of the approaches to mitigate climate change-related issues such as GHG emissions. According to R7, the South African government has come up with an IRP dated 2023, which aims to transition towards green energy forms as a sustainable approach. The energy welfare or security for future generations was also put into the lens. R7 mentioned that the coal reserves will be depleted in the future; hence, RE provides an opportunity for reliable energy.

Concerning energy insecurity, continuous load shedding affects economic activities, and the trust people have in politicians operating within specific local governments. Renewable energy provides extra supply onto the grid in a way that, to some extent, alleviates energy shortages. Even most of the interviewed key informants (R2) stressed that in addition to reducing load shedding, reliable energy supply attracts economic investors from various sectors. When it comes to energy security, the Newcastle municipality envisions supplementing energy demands in surrounding towns such as Dundee, Dannhauser, and Nqutu, which are not technically capable of implementing such projects (R7).

Figure 8 2: Responses to the benefits of RE to local government.



8.3.3 Barriers

The participation of local municipalities in energy production is likely to face several barriers. In this regard, obstacles that may impede the implementation of RE production systems are referred to. This section describes these barriers, while the challenges will be explained in the succeeding sections. From the interviews conducted, barriers were identified, including financial capacity (R7).

The ownership structure of the entity serves as a key factor contributing to financial barriers. According to R7, local municipalities lack sufficient funds to establish and sustain new technologies independently, necessitating external support. Financial constraints also pose additional challenges to municipalities in terms of human resources, a problem not limited to the Newcastle municipality alone, as highlighted by R7.

To address these challenges, R7 proposes that the energy department should operate independently within the organisational structure, requiring budgetary considerations. However, leveraging funding from state agencies like DMRE and the national treasury proves challenging. Despite attempts by the Newcastle municipality to engage them, success has been elusive. R7 identifies several reasons for the difficulty in securing funding from these state organs. Renewable energy, being an emerging field lacking established business models, raises government scepticism regarding support and allocation of funds.

Moreover, municipalities lack the financial capacity to hire business experts to develop robust business models. R7 recommends that COGTA support local governments by assisting in conducting market research and developing business plans that are more likely to receive funding from the national treasury.

8.3.4 Summary

The empirical findings indicate that the majority of local municipalities are considering implementing RE in the energy mix, while some are already doing so. Several benefits of transitioning towards RE are employment creation, building political strength, mitigating climate change, protecting the public from unhealthy energy forms, contributing to economic development, alleviating energy shortages and load-shedding and cost reductions with the cost of effect business.

There are barriers to RE transitions. These are mostly financial and human capacity issues. Municipalities do not have enough capacity to accommodate a standalone RE department. Even if municipalities try to leverage funding for that, they are constrained by financial support to develop sound and fundable business plans.

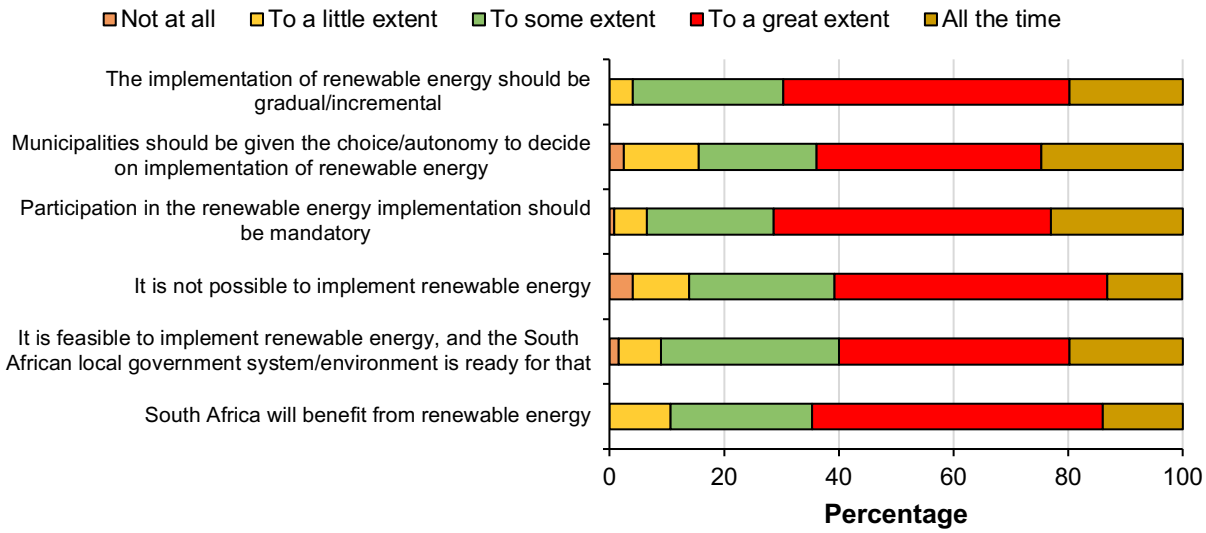
8.3.5 Recommendations

- COGTA should develop policies to recognise RE as a sustainable business and capacitate local municipalities with business skills, such as generating profitable business plans that attract governmental funding from financial agencies like the National Treasury.

8.4 The Technical, Economic, and Environmental Feasibility of Supporting Households and Economic Entities with Implementing RE Systems

Stakeholder interviews and surveys were conducted to gather different perspectives on the technical, economic and environmental feasibility of implementing RE at the local municipality level. Diverse views were given concerning the feasibility of implementing RE energy in the local municipality atmospheres. Figure 8 23 indicates the results of the survey conducted to understand the feasibility of implementing RE in local municipalities concerning how the process should be done, the decision-making process, enforcement policies, the readiness of local government to implement RE and assessing whether it is worth doing. Survey results show that the implementation of RE is feasible (Figure 8 23). It takes a technological, economic, and environmental perspective, as evidenced by the literature (Section 4.2).

Figure 8.3: Responses on techno-economic and environmental feasibility of implementing RE systems by local municipalities (n=123)



8.4.1 Social issues and the policy, institutional and regulatory landscape

The majority of respondents (50%) agreed, to a great extent, that the implementation of RE should be gradual (

Figure 8.3). This statistic is in tandem with the stakeholders' views that there are potential job losses likely to be faced, like in the coal value chain. In this regard, the process should set up structures to ensure that the implementation is done in an economically and socially acceptable manner. A respondent highlighted concerns regarding employment across the coal value chain, anticipating potential resentments from affected parties. Local municipalities, mandated to foster economic development within their jurisdiction, must carefully consider this aspect. Municipalities must seek assurances from RE providers that the transition process will create jobs without displacing existing ones (R1).

> *…issue coming up soon of curtailment and another issue that that that is going to come on board is the extent to which REoperations uh that platform can coexist with your traditional fossil fuel ones because you don't want to have one completely obliterating the other. And then you can have huge problems in terms of unemployment. There's gotta be a transition where the influx of REvendors and REplayers does not displace the existing ones. So that level of harmony is going to be quite crucial in the not-too-distant future, particularly because you don't want to have a RE program at the expense of people being employed R1.*

The other aspects concern whether the municipality should be given autonomy to implement renewable energy. In this regard, most respondents (65%) agreed that this should be done (

Figure 8.3). If local municipalities are given the liberty to purchase electricity directly from IPPs, they will be able to operate their revenue sustainably. The draft of SAREM has included the liberation of municipalities to purchase their energy directly from IPPs (DMRE et al., 2023). This inclusion creates opportunities for their revenue streams, as mentioned by R1, R2, R4 and R7.

> *I think the idea of the end goal is for our municipality to also purchase energy from IPPs and then not so that the in-concert idea of the policy is to write it in such a way that our electricity department will have the power to deal with these types of things and not every time go to council. So it's to make it easier once the national government allows us to purchase from independent power producers... It's not easy, but that's what we try to do with that policy to purchase from IPs as an electricity department in future R4.*

Transitioning to the RE pathway addresses several issues of both national and international concern, such as climate change, resource extraction, energy insecurity for future generations, and the future of economic development. This trajectory needs a strict approach in all governmental atmospheres to communicate a single language. Thus, RE must be mandatory for everyone. A significant proportion of respondents (>60%) strongly believe that participation in RE should be mandatory for all local municipalities (

Figure 8.3). It is a question of integrating policies that guide municipalities in strictly enforcing the RE agenda.

8.4.2 Technical feasibility

Interview respondents further emphasised the point that technical feasibility is not a challenge when it comes to implementing RE (R1, R2, R6 and R7). They attributed this to the availability of conducive conditions such as adequate radiation and wind. According to R1, each local municipality should find what is the best technology for their area based on existing maps available in the database.

> *Look what it's feasible or not is another story. I can tell you now just off the top of my head, I have seen it happen. It is feasible, but I told you the problem is that from a governance point of view, municipalities gotta get the houses in order R2.*

Apart from conducive climatic conditions for harnessing solar and wind energy, there are a lot of organic materials for waste-to-energy projects. According to R2, there is a lot of animal manure emanating from cattle production, piggeries, poultry and dairy farms in areas such as the uMgungundlovu District. The respondent pointed to the challenges in waste management at landfill sites and wastewater treatment sludges as possible opportunities for waste-to-energy projects. Private companies may negotiate with local municipalities to develop contracts that allow them to symbiotically manage organic wastes. Such concessions should be 20 to 30 years long to allow enough time for returns on investments (R2). However, from a techno-economic point of view, waste in the energy sector is a grey area that needs many optimisations through science and innovation and the application of best practices. In this regard, there are protocols to be followed in terms of licencing and standards and norms to follow. According to R7, there are no established policies to regulate SSEG within their local municipality. Municipal laws should regulate the generation of energy above the expected limit for each generator. As a result, they have been engaging COGTA and SALGA for assistance in developing context-specific regulations for renewable energy. There is a policy gap in this area in terms of sustainable management of waste-based projects.

Land availability is not a challenge when it comes to renewable energy. According to R1, R2 and R6, there is enough land in South Africa to support renewable energy. R6 reiterated that the focus should be on financial and human resources, not land. Even Newcastle municipality is considering making use of the airport land, which belongs to the municipality, for RE systems.

8.4.3 Economic feasibility

Economic viability is another issue of concern when it comes to investments in certain technologies. Local companies are business entities that earn revenue through activities such as buying and selling electricity. Therefore, any transition should not negatively impact their income generation. R1, R2 and R6 mentioned innovativeness in terms of the economic feasibility of renewable energy. One issue is leveraging international markets and linking with other sector value chains. Products made from low carbon footprint innovations have high returns on investments due to the absence of carbon taxes. R2 and R6 highlighted the importance of RE in alleviating energy insecurity, which has multiplier benefits such as increased local investments due to guaranteed energy availability. It has socio-economic benefits such as local economic development. Even respondents from a survey in

Figure 8.3 show that renewable energy is more likely to bring benefits.

> *And once you can do that in a way that mitigates the impact of both load shedding and climate change, then the local government becomes an investor, investor-ready destination R2.*

8.4.4 Environmental feasibility

Environmental feasibility is not an issue of concern when it comes to clean energy sources such as solar, wind and hydro. Perspectives from R1, R2, R3 and R4 show that RE is environmentally friendly. R3 raised an idea about RE implementation as an approach to sustainability compliance as per the SDGs. In this regard, their municipality is making efforts to include it in their energy mix and provided an example of simple solar power systems for heating in their municipal offices.

> *So whether it's energy or it's water, whatever the service is may be the technical, economic and environmental feasibility is there R2.*

Local municipalities are ready to implement RE, taking into consideration the environmental, technical and socio-economic perspectives, as corroborated by the survey results in

Figure 8.3. However, a small group (1.6%) that perceives the local government as unprepared believes that governance structures need to be established beforehand, as outlined by R2. Additionally, R6 and R7 identified several hindrances, such as financial constraints and inadequate human resources.

8.4.5 Summary

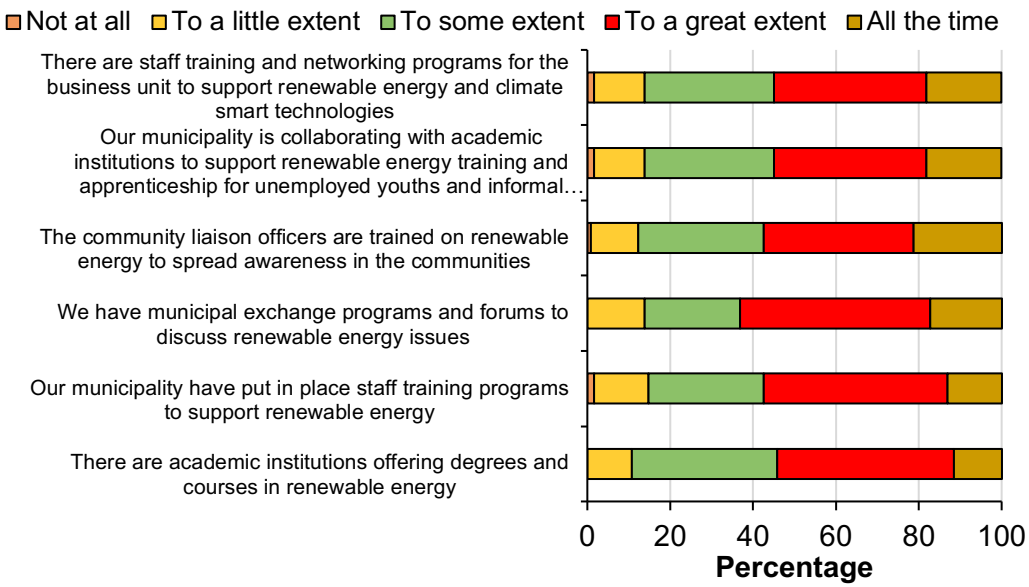
Empirical studies were conducted to evaluate the economic, financial, and environmental feasibility of implementing RE systems in local municipalities. The implementation of RE should be gradual, allowing for:

- Municipalities to have autonomy in implementing renewable energy initiatives.
- Addressing various national and international concerns, including climate change, resource extraction, energy security for future generations, and the trajectory of economic development.
- Adopting RE to be mandatory for all stakeholders.
- Regulating SSEGs within local municipalities in the absence of established policies.

8.5 Skills Required by the Local Government Sector in Promoting RE Systems

Empirical studies were done to assess the municipal capacity to implement RE concerning available and required skills and human capacity development strategies. Online surveys took different views, which were upskilling and reskilling activities, collaboration with academic institutions, community mobilisation and development, participation in development programs and the relevance of academic institutions in skills development. The online results are thus reported in Figure 8.4, with the majority of the respondents (>50%) agreeing that all the aspects mentioned above of skills development are available within the local municipalities. The following sections further describe outstanding issues to be addressed on route to the implementation of renewable energy.

Figure 8.4: Responses on skills development in local communities



8.5.1 Staff training and networking programs

There are staff training and networking programs for some municipal business units to support RE and climate-smart technologies. However, this is not taking place in some municipalities, where almost 12.3% confirmed that this is only to a small extent. An interview with R3 confirmed that their municipality is part of the South African Cities Network, but they have not been actively discussing the idea of a RE agenda. However, a survey shows that 45.6% of the municipalities are largely involved in the South African Cities Network, where RE issues are discussed. R4 confirmed this view that the DMRE coordinates networks amongst the municipalities where they sit together and share knowledge and experience on certain issues. South Africa has various networking and information-sharing platforms, such as the C40 group of cities, UCLGA and ICLEI (SALGA, 2021). With these vast platforms, local municipalities may share knowledge and experience on the implementation of renewable energy. For example, several municipalities, such as Nelson Mandela Metropolitan Municipality, Ilembe District Municipality, Richards Bay and eThekwini Metropolitan Municipalities, are at the advanced stages of RE implementation (R1, R4). They have much experience and knowledge to share with other municipalities through the existing platforms.

Staff training is an important aspect of driving the RE agenda. This training should be focused on different actors within the local municipality organogram. At the top management level, there is a lack of knowledge on the importance of RE as a revenue generation stream, solution to energy security and sustainable energy form for current and future generations. This lack of awareness was raised by several respondents (R1, R2 and R5). R1 mentioned the lack of interest by rural decision-makers in implementing energy initiatives as a problem. Local governments set up development targets in their IDPs where RE is not prioritised due to their

attitudes towards conventional activities, which could include industry or existing operational methods. The same challenge was faced by R5 when they tried to submit a proposal for a RE project in one of the local municipalities. Their proposal was not given attention, and no response was received. This type of response implies that strategic development skills are required in some of the local municipalities (Approximately 13% of them, see Figure 1.) In this regard, SALGA plays a role in coordinating strategic planning training in alignment with the national development agenda.

> *In my municipality, no, there's no project that is available at the moment besides the proposal that has been done. And last time, and it was politically suppressed, as I mentioned before, that and everything in the municipality, you find that it is politically it should be more politically motivated to go through R5*.

Currently, most municipalities depend on conventional energy forms. Renewable energy is coming up with new areas such as manufacturing, installation, generation, wheeling and marketing. The skill sets required include engineering, which encompasses design, installation and maintenance (R1). Soft skills that can be required include data capturing, which individuals do with at least a matric certification. However, R1 argued that these skills are not relevant to the local government but can be applied by the private sector, which is doing the project. R4 confirmed that they do not have any of the skills required in the RE space but mentioned the need for a consultant. However, in the case of R4, it would be that they are already an established municipality. This means that the local municipality should be a catalyst to drive activities within its area of jurisdiction but not extensively involved in operations on the ground. Staff training could be needed for administrative activities like marketing, finance, and public relations.

> *OK, I don't know if there's a. If there's, I don't know if there's a discrete set of skills that are required for this particular sector because you need to expand what? R1.*

Marketing and public relations skills are crucial to putting the municipality in the competitive RE business. Conventionally, local governments are purchasing energy from Eskom and selling it to customers, thus acting as a middleman. R1 and R2 emphasised the advantages available within local municipalities to operate profitably if they can mobilise their available resources and create an enabling environment to attract investors. With the success of the DMRE's renewable strategic plan, competition amongst municipalities will ignite. In this regard, marketing and public relations skills will be vital, and if they are available, the officers should have basic RE knowledge.

8.5.2 Collaboration with academic institutions

Engineering skills are crucial in the RE transition process. Research and innovation play a role in selecting the best and most adaptable technologies that are easy to operate, environmentally sustainable, socially acceptable, and economically viable. Such academic institutions play a role where universities are the hubs for knowledge creation and technology transfer while local municipalities are, in conjunction with the private sector, technology implementers. This is being taken into consideration, as well as collaboration with academic institutions to support pilot projects and training for unemployed youth and informal technicians, as evidenced by the survey results (

Figure). R3 confirmed their willingness to collaborate with academic institutions in their RE agenda. During the interview, they mentioned their plans to engage the local university in the RE space.

On the other hand, R4 mentioned their long relationship in research and collaboration with Nelson Mandela University. The research memorandum of understanding dates as far back as 2008. Along the way, numerous master's students developed various technologies, amongst others, best-performing solar panels.

> *I think when we started we had a close relationship with the Nelson Mandela University. So we worked closely couple of other ways of collaboration and that's why we implemented it and 2008 we did the first pilot on Went Small Went which was the House where I went batteries and PV panels so it so so that was a little relationship there…And we could explore that more, I think that relationship still standing, but I think we could do more to implement renewable energy, especially in our sector…Whatever, and we learn from each other, especially with the master's students R4.*

The issue of technology optimisation was also brought forward by R1, who, in addition to engineering skills, mentioned the importance of academic institutions in driving that aspect. Academic institutions may not directly provide skilled labour in the municipality's RE sector, as issues such as budget constraints come into play. However, these will be described in later sections. There must be mechanisms by which these skills are absorbed into the labour pool. According to R2, much of the work necessary for RE is locked in academic theses and has not been implemented. R2 further argued against the idea of staff upskilling or reskilling and the implementation of training programs, where these ideas are not being implemented. Based on their opinion, Universities may act as technology research, development and transfer centres while vocational centres focus on technical skills development.

The academic stream I look at is the vocational stream because that's the training that needs to come in, not theoretical, but actual practical on the ground or what I call extension services type of training R2.

8.5.3 Community engagement and participation

Equitable access to energy should consider the indigent groups and communities. This forms part of the municipal responsibility as enforced by the Municipal Systems Act (2000). Many projects risk failure when implemented in isolation, treating communities as mere technological adopters. Involving communities in all stages of project development – co-identification, co-selection, co-testing, and co-implementation of technologies – fosters a sense of ownership, enhances understanding of operations, and promotes appreciation of resulting benefits. R2 expressed concern about the lack of community involvement, identifying it as a major drawback in the RE discourse.

Additionally, the respondent highlighted issues such as cable and electricity theft as hindrances in the energy sector, emphasising the need for an integrated approach to address them. Good governance, where communities have a voice in municipal operations, was deemed crucial. Education and awareness initiatives in local communities are imperative to address these challenges effectively.

If you go you remedies burgers today, go to the cops, store back in the early 2000s, and late '90s, there was an informal settlement just outside there. Some municipalities decided as part of the RDP program they went and put in pit latrines. They didn't consult with the community that stood there for close to 10 years in that cop's full area you all use over empty toilets. None of the communities went there, they said. Nobody came and spoke to us about what we wanted. They just built the thing and they expected us to settle it. So, there's an example of something that failed, but there's a lesson coming out of the talk to people. People are not there just to be herded. They want to be heard, not to be just, you know, channelled at treated as though they don't know what they want R2.

Hence, the municipal liaison department plays a crucial role in leading community engagement efforts and awareness campaigns in the renewable energy (RE) sphere. According to the survey findings, approximately 36.1% of community liaison officers are extensively trained to disseminate awareness in communities (Figure 4), while about 12% have received limited training. This figure aligns with insights provided by R3, indicating that although their local municipality has a community liaison department, staff members lack training on renewable energy. The 0.8% of respondents who report no such training in their local municipality may

predominantly come from rural areas. Notably, one respondent from a rural municipality (R5) highlighted the absence of a dedicated electricity department. This highlights the unequal distribution of green energy initiatives across municipalities, with a predominant focus on urban areas over rural regions.

8.5.4 Summary

Empirical studies were conducted to evaluate municipal capacity for implementing RE, focusing on available skills and human capacity development strategies. Staff training emerges as a crucial factor in advancing the RE agenda. SALGA plays a role in coordinating strategic planning training that is aligned with the national development agenda. Academic institutions serve as hubs for knowledge creation and technology transfer, with universities playing a significant role. Local municipalities, in collaboration with the private sector, serve as technology implementers. Ensuring equitable access to energy requires consideration of indigent groups and communities. However, community involvement in all stages of development is essential for success.

8.5.5 Recommendation

- Training should be focused on different actors within the local municipality organogram. At the top management level, there is a lack of knowledge on the importance of RE as a revenue generation stream, solution to energy security and sustainable energy form for current and future generations.

8.6 International and Regional Best Practices for Implementing Sustainable RE Systems

South African municipalities have the opportunity to learn from regional and international communities how to implement RE systems. Questions on international and regional best practices were administered, yielding limited responses, with only two key informants providing information. Major best practices identified include understanding the organic waste-to-energy stream, fostering PPPs, introducing RE courses, and financing a RE centre.

For instance, in the realm of organic waste streams, further exploration is needed regarding environmental impact. Countries like the Netherlands have developed efficient technologies with lower emissions, highlighting avenues for potential learning and improvement (R1).

Table 3: Matrix 1 - Participant responses regarding the international and regional best practices for implementing sustainable RE systems

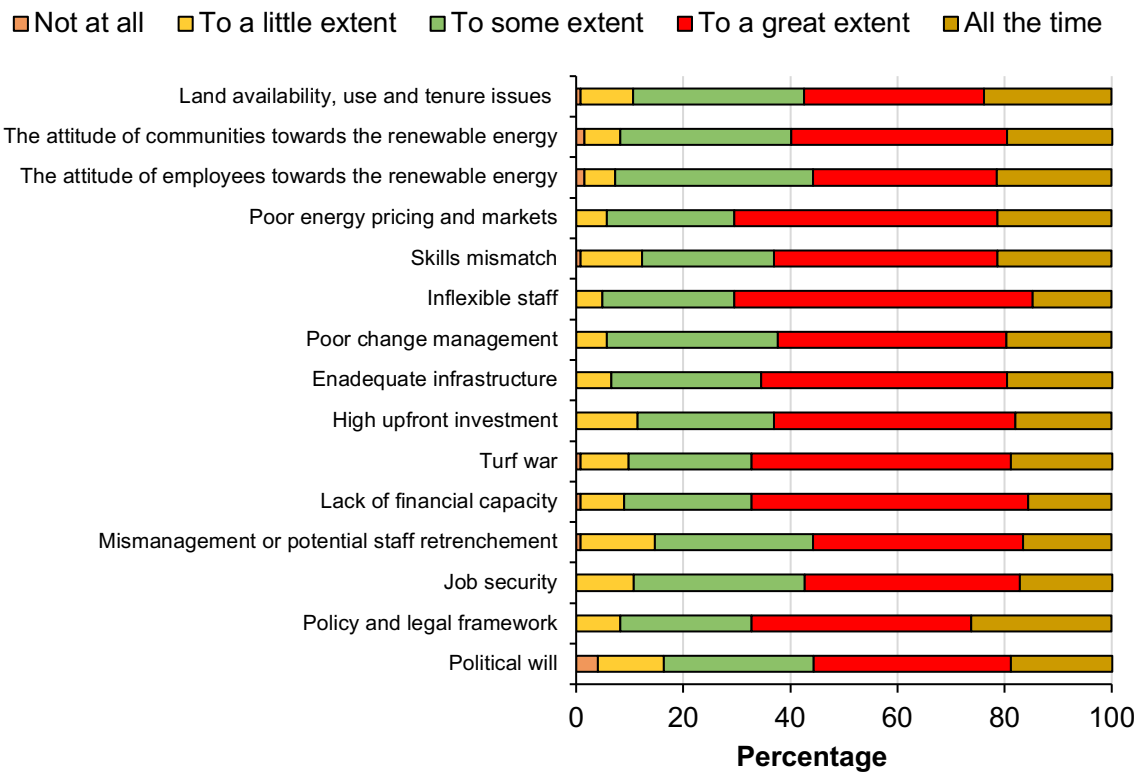
Sub-question	Respondents' responses	Sources
In your opinion what are the global and regional best practices in the implementation of RE systems that could be adopted in your municipality? What efforts have been made by your municipality to collaborate and partner with both local and international stakeholders to implement RE systems?	*Uh, and also the other important thing that I like is about the best practice, especially this sector of waste to energy. Ohh, where we uh, which is just more gray and being given focus once there are a lot of issues to deal with emissions, is it teams elementally friendly? Is it sustainable outweighing the challenges?*	R1
	As you are aware, I'm currently based in ... and they believe there is strongly in the concept of the triple P so I think the best practice that can be well that South Africa can try to adopt is the involvement of industries or private entities in the development of RE technology. *This RE is a course in universities and other technical colleges, there are some universities and colleges that have that, but there should be renewed effort and the government can come out to sponsor such kinds of initiatives.* *So the best practice like in well in, in, in other countries I have had the opportunity to be in Germany, although that was a long time ago. You would find that the government would sponsor a centre at a university for renewable energy. I started the Center for Water and Renewable energy and I do not know whether that center still going on. There is a centre in Ohio. The University of Stellenbosch is doing very well. It's supported by the Germans, so if we could have also that kind of thing happening, Ohe governments sponsored sponsoring those, those kinds of centres, they would cut analyze the development of technology at the national level.*	R6

8.7 Challenges the South African local government can face in promoting RE systems

The transition to RE is not hindered by municipal structures supporting it, available feasibility information, and international and regional best practices. However, despite its potential to contribute to economic development, energy security, and sustainability, its implementation faces obstacles. This section presents empirical findings on the reasons behind the lack of RE implementation and identifies potential barriers likely to be encountered during the implementation process.

Figure 8.4 shows responses from online interviews on the challenges likely to be faced when implementing RE. These have been categorised into land tenure issues, attitudes and perceptions from local communities and officials within the energy sector, pricing and marketing availability, skills mismatch, staff flexibility, change management, infrastructure, investment costs, turf war, financial capacity, mismanagement, job security, policy and legal framework and political will.

Figure 8.4: Responses on challenges the South African local government can face in promoting REsystems (n=123)



8.7.1 Land issues

Land issues might impose a challenge when considering issues such as tenure and land availability. Based on responses obtained from interviews with various respondents, the land issue is not a problem. The respondent from Botswana University (R6) believes that there is enough land in South Africa to support RE. The same was indicated by a respondent from the Newcastle municipality (R7), who indicated that they are considering the use of derelict Eskom infrastructure within their municipal area and at the local airport.

Land availability may vary for different purposes, posing challenges for RE projects. In such scenarios, reconsideration is essential, potentially reallocating land for RE manufacturing (R1). R1 highlights that land use is not solely about generation; it encompasses various activities along the RE value chain, including manufacturing, generation, wheeling, and distribution. If land is not feasible for generation, it can be repurposed for manufacturing, as exemplified by Greentech Atlantis in Cape Town. Here, the city is witnessing significant investor interest in manufacturing RE infrastructure components. Hence, municipal openness to such initiatives is crucial.

The other issue is not about having adequate land but being innovative to ensure that the land is fit for a purpose. According to R1, municipalities that do not have adequate land to generate energy may find innovative ways of compensating for excess energy coming from other municipalities, which the respondent phrased as ‘oiling the wheels’ in meridian economics. The land may not be suitable for energy production, but according to R1, land rezoning can be done or reworked by the city council to make sure that it is fit for purpose.

> *So let me give you a classical example. If somebody wants to set up a wind farm in a municipality, that means the palatines gotta be able to let them know quite quickly. Well, how much land is available for that? And then once that happens with it's a window or solar farm, the necessary due diligence has got to be performed to make sure that it doesn't conflict with, whatever the purpose that land is for R1.*

8.7.2 Social perception and attitudes

Social perceptions pose a significant hurdle to RE adoption, as highlighted in a survey reflecting the attitudes of municipal officials and communities, emphasising the crucial role of change management (Figure 8.4). Notably, respondents (R1, R2, R4, and R5) stress the negative attitudes of top management officials, who exhibit resistance to change and cling to traditional operational methods. For instance, R2 points out how some managers prioritise sectors like agriculture, mining, or textiles, fearing revenue disruption and job losses if they transition to RE (R1). R5’s experience underscores this issue, where attempts to propose RE

initiatives to local municipalities faced obstacles. Furthermore, a lack of awareness regarding the benefits of RE exacerbates this resistance.

> *In my municipality, no, there's no project that is available at the moment besides the proposal that we did. And last time, and it was politically suppressed, as I mentioned before, that and everything in the municipality, you find that it is politically it should be more politically motivated to go through R5.*

R1, R2 and R5 suggest that top management should attend staff development training, which SALGA coordinates. R2 emphasised the importance of evidence-based information on how these renewables are likely to improve revenue flows directly and indirectly. For example, minimising waste entering landfills, which, when not well managed, will affect the municipal revenue stream.

Local communities are also neglected in such projects and act as net technology receivers. As a result, they might reject such interventions, raising other social issues such as cable and electricity theft and infrastructure damage (R4). According to R2, community participation is not about telling them what you want to do but about consulting with them about what they want and involving them in the whole process.

> *When I spoke about Community participation, I just don't mean, you know, you go and tell the community. This is what we wanna do. It should meaningfully engage with communities in looking at what their needs are, what are their aspirations and what matters to them R2.*

8.7.3 Energy pricing and marketing

Poor energy pricing and markets are some of the challenges raised (Figure 8.4). Renewable energy is a grey area likely to be affected by market dynamics and pricing. The local municipalities should be innovative in enhancing markets for renewables. R2 gave examples of the EU, USA and China as major destinations for green products. For example, manufacturing electric cars powered by solar panels is likely to fetch competitive prices in the market (R2). The other thing is that commodity prices are not going to be driven by shortages as is the case with LP gas, petrol and fossils (R2). To achieve this, local municipalities need to clarify their long-term investment targets and goals for using RE as a revenue stream before weaning themselves from Eskom (R2). However, these issues have been addressed in the new DMRE strategic planning document, where energy pricing and marketing issues have been explained (DMRE et al., 2023).

8.7.4 Skills and expertise

Challenges such as skills mismatch and inflexible staff impede RE initiatives, as indicated in Figure 8.4. While some local municipalities benefit from existing electricity departments, which may require reskilling, rural counterparts often lack dedicated energy departments. For instance, R5's interview revealed the absence of an energy-specific department in their rural municipality, a situation echoed in other studies (Averchenkova et al., 2019). Stakeholder insights highlight the complexity of the skill issue; while SALGA has initiated some reskilling efforts, new skills are still deemed necessary (R4). Recommendations include establishing dedicated RE departments within municipalities, as seen in examples like eThekwini municipality, according to R7. R6 underscores the importance of placing the right individuals in relevant positions, emphasising the need for skilled personnel.

8.7.5 Infrastructure

Inadequate infrastructure is a challenge when it comes to RE adaptation (Figure 8.4). It has been reported that Eskom does not have adequate infrastructure as it is battling with existing facilities (Eskom, 2019), thus confirming the findings from the surveys. In addition, the lack of grid access is one of the major challenges. Before local municipalities engage private investors, they need to know how much grid space is available in that area. Certain regions face saturation issues, restricting additional grid connections (R1). To address this, there have been calls to open up the grid to accommodate more users. Notably, KwaZulu-Natal stands out for its relatively open grid compared to provinces like Northern and Eastern Cape (R1). Taking cues from this, Newcastle municipality is strategising to leverage underutilised Eskom infrastructure to create more grid space (R7).

> *So some places are saturated and they can't put any more project projects, whether renewable or anything onto the grid R7.*

Apart from inadequate infrastructure, high investment costs may be a challenge. A survey conducted shows that high investment costs undoubtedly play a significant role, as confirmed by 100% of the respondents. It also confirms findings from the literature where Eskom is battling to replace aged infrastructure (Eskom, 2019). Even if they are to resort to renewables, there is a need for energy storage facilities (eThekwini municipality, 2020). When it comes to energy from biomass infrastructure, investment plays a crucial role (R6). According to R1, investment should not solely focus on infrastructure but on security. Some social ills are likely to come into play in terms of infrastructure damage and theft, with R1 suggesting that proper structures and good policing should be established, with the same applying to community involvement:

But I think from a tax point of view and investment, investment, security, so from local government, the whole issue of the social side where if you put in infrastructure, no criminality goes and destroys its infrastructure R1.

8.7.6 Turf war

A turf war is defined as a dispute or fight between two parties over a certain territory or activity. In this context, we refer to municipal competitors likely to delay or derail the RE agenda. Responses from the survey show that this is most likely to happen in the RE transition space (Figure 8.4). Some of the questions emanating from these are: (i) Will Eskom accept that they have failed and give room for municipalities to purchase directly from IPPs, and (ii) Will coal companies allow RE while stopping fossil fuel that has been utilised for more than 500 years? The literature sheds light on a turf war, with coal industry unions resisting job losses. A similar scenario unfolds with Eskom, which holds significant sway in the energy sector (DMREDSI and DTICC, 2023). Acting as intermediaries, municipalities lack the authority to regulate electricity generation and distribution, as they operate within the orbit of Eskom (R1).

So I think the energy field is becoming very, very fluid very, very quickly and and and and you know traditionally the, the, the, the, the local government has often said well you know we don't rock the this, this, this horse, the apple cart you know we've got a revenue stream that that we get as being the middleman between Eskom and the and the consumers R1.

The turf war issue has been identified as politically driven. As per R7, certain local municipalities – governed by specific political parties – may exhibit reluctance to cooperate with opposition parties. To effectively address this challenge, it is suggested that representatives from all political parties be convened and that collective engagement be facilitated to foster collaboration in tackling the energy crisis (R7).

So, at the moment, there's no engagement and you must know the municipalities are coming from different political backgrounds and at times when they help a municipality that is not part of them, it becomes a small problem R7.

8.7.7 Socio-economic challenges such as job security

The potential loss of jobs in the coal value chain poses a significant challenge for communities, as indicated by a survey where most respondents foresee substantial job losses. R1 emphasises the necessity of a strategic approach to ensure the coexistence of renewable energy (RE) and fossil fuels. It advocates for a transition process where RE vendors and

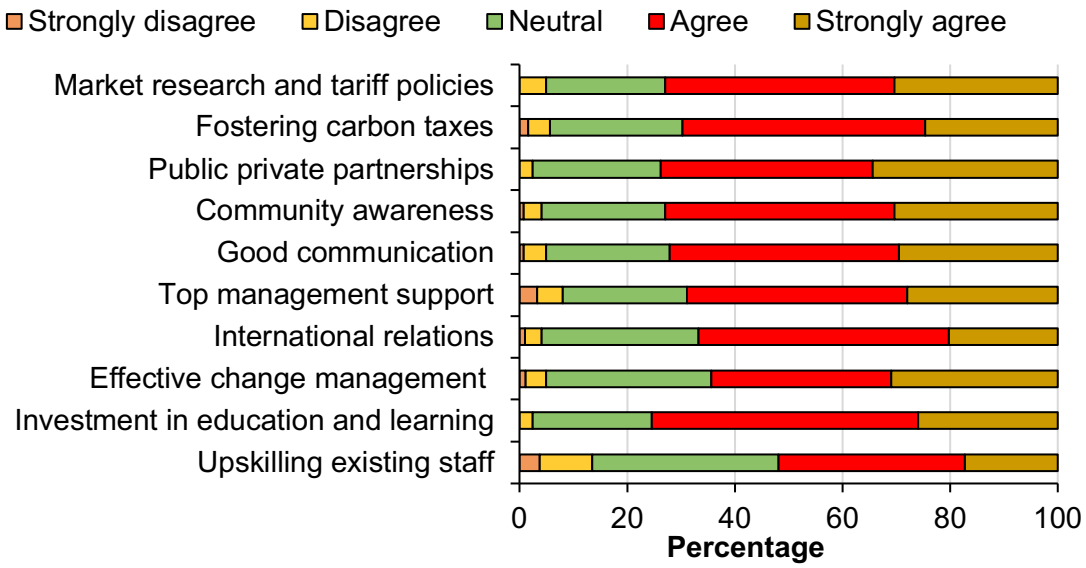
players complement rather than replace existing ones (R1). Failure to adopt such a strategy could render RE unappealing to municipalities.

> *And so it goes to the issue that you raised of skills and earlier on as well and because they should be, they should be a program and a process to absorb entrance, absorb workers in the one fossil fuel-based energy derived program to a low carbon 1 without there being too many job losses because that will then also I I'm assuming that will then also make the renewable space far more umm attractive to municipalities where there is huge unemployment issues currently you know you don't want to have a municipality R1.*

8.7.8 Addressing the challenges

Studies were conducted to assess the approaches required to address challenges faced in RE (Figure 8.5). These relate to marketing and tariffs, carbon pricing, PPPs, community awareness, communication, top management support, international relations, effective change management, investment in education and learning and upskilling and reskilling of staff.

Figure 8.5: Results on the solutions to challenges faced in RE



8.7.8.1 Market research and tariff policies

Market research and tariff policies have been included in the draft SAREM (DMRE et al., 2023). According to R4, their municipality is working on the tariff structure to ensure that RE does not interfere with municipal income. They have even hired experts to do the work for them.

8.7.8.2 Fostering carbon taxes

Economies are transitioning to low carbon. The market doors for low-carbon products are likely to open while the fossils close. According to R1, there is going to be a time when exported products are going to be purchased based on their carbon footprint. Thus, based on a survey conducted, most respondents believe that fostering carbon taxes can be an approach to market RE.

> *This carbon border adjustment mechanism is something that you can investigate further and you'll find that in two or three years, a lot of those export doors are going to be shut to local exporters unless they there can mitigate how they, how they produced that thing R1.*

8.7.8.3 Public-private partnerships

The public sector cannot carry the load alone if not partnering with the private sector in terms of investment boosting, expertise exchange and productivity. Most respondents fully agreed that PPPs are important in pushing the RE agenda. The issue of PPPs in addressing developmental challenges is debatable. R1 had a different opinion on the success rate of PPPs and suggested that this should be looked at. However, R2 mentioned that sometimes PPPs may serve the interests of the company to earn profits at the expense of communities. In this regard, the success of PPPs depends on the model used.

> *I think I think you should maybe I don't know, but maybe you should look at the success rate of PPP umm in, in, in South Africa, you know how long it's taken to get them off the ground and stuff like that? R1.*

8.7.8.4 Community awareness and communication

Local governments are mandated to serve the communities within their jurisdiction. In this regard, awareness of RE is crucial for its acceptance, adoption and participation by communities if implemented as agreed by most respondents (R2, R3, R5, R6). R6 emphasised educating communities on renewable energy aspects such as the installation of solar rooftops. They further explained that communities need to be taught that RE is an alternative energy source that they utilise to alleviate their energy crisis:

> *…..that the municipality can encourage the adaptation to uh renewable energy by firstly providing sufficient information and education in the Community in so far as the use of renewable energy is concerned, and also by making them aware of that renewable energy as an alternative to the normal, at a power that we, I used it to R6*

Furthermore, the communities may be educated about the economic use of renewable energy because it is not like base load emanating from conventional national grids (R6). In this regard,

people need more education on energy storage using batteries. Community awareness programs can be channelled in different ways. R5 gave examples of distributing pamphlets in public places such as schools and their municipality website was updated with renewable energy solutions.

8.7.8.5 Top management support

A large proportion of individuals who participated in the survey agreed that top management support is important. The results in Figure 8.5 show that in response to a question of whether top management support can be a solution in promoting renewable energy transition about 27.9% strongly agreed, 41% agreed, 23% were neutral, 4.8% disagreed and 3.3% strongly disagreed. This idea of top management support has been mentioned extensively in literature. Poor policies, governance and strategic planning may derail the municipal vision and mission as well as deter investors (Averchenkova et al., 2019). SALGA and COGTA have been mentioned as participating in training municipal staff. According to ro R6, the training is administered to the technical and administrative staff. Hence, there is a need to extend this to the top management within their municipality. Furthermore, R6 emphasised the issue of political differences as a major problem which needs strong engagements with political parties. To achieve that the top management should have adequate stakeholder engagement skills.

> *My first day would be that, yeah if we can get. To engage the municipality to engage with the political leadership and get a consensus on this issue of renewable energy. In any way, we will need the police will need the political will to be successful in this. In this endeavour, uh, suddenly I think the municipality, the senior management of, …..R6.*

Training should not only be limited to top management but also stakeholders; political and influential people. According to R3 the training of traditional leadership should not be overlooked. These are the people in direct contact with communities, especially in rural areas. They need to understand the concept of renewable energy and how it benefits communities in energy security. The interviewee provided examples of the experience encountered with training traditional leadership at the community level and political leadership at the council level.

R7 argued that top management training may not be an issue because any good manager can lead a municipality regardless of knowledge in the field. In this regard, the selection of a competent manager is crucial. However, R3 had another view of top management training. The training packages should be specific for certain groups of people, highlighting the emphasis on renewable energy at micro and macro-economic scales, and social and environmental perspectives.

Like I told you when I used to do capacity building, I call it capacity building in causing the hotel when you're training people, it's a different type of training that you would give to a technical person versus I'll say a decision maker, particularly politicians or senior executive managers…… They're not interested in the in the in the technical aspects of the training. They're interested in seeing what the benefits are from an economic perspective, from an economic development perspective, from a social stability perspective R3.

8.7.8.6 Effective change management

As shown in Figure 8.5, responses to questions on the influence of effective change management on renewable energy transition and adaptation in local municipalities show that 30.9% strongly agreed, 33.% agreed, 23% were neutral and 4.8% disagreed. This implicate that the top management needs strong skills in developing and implementing comprehensive result-orientated adaptive and transformational strategies to spearhead renewable energy implementation in local municipalities. This is achievable with adequate training as discussed in previous Section 8.7.8.5. When looking at the literature, the top management priorities derail the integration of RE in IDPs and subsequent implementation (Mirzania et al., 2023; Yaqoot et al., 2016). The need for effective change management was emphasized by key informants (R2, R7). R2 explained the lack of priorities towards RE as a hindrance as top management is resistant to new emerging green technologies. The informant highlighted that there must be a shift in paradigm from conventional revenue generation stream and theoretical perceptions towards RE to practice and action on integrating the green idea within their revenue streams, taking advantage of resources available at their disposal to use. Furthermore, R7 overlooked the issue of financial constraints and argued that money is never enough to satisfy our goals but prioritisation plays a role.

I don't think the issue may be financial resources are passing to a great extent. It will be a priority. No country will ever say that he's got enough money. We will always look for more and if we have enough, we will stop working and just sit at home. So the literal resources that we have, can we prioritize them so that we go, I mean we are pushing some for the renewable energy R7.

8.7.8.7 International relations

Renewable energy is a grey area in local municipalities, deficient in information regarding best practices, policies and skills. Interactions and collaborations with international communities are pertinent. A survey reported in Figure 8.5 concerning the importance of international relations on renewable energy transition within local governments shows that 20.2% strongly agreed, 46.5% agreed, 29.2% were neutral and 3.1% disagreed. This agrees with the findings

from the literature review and expert interviews. According to R2, from research and development from a technological improvement point of view, international expertise may assist us in optimising and adapting renewable energy to our local conditions. Even some of the technologies from, for example, Europe, are advanced in terms of resource use efficiency and minimum emissions.

> *And I mean, yeah, you know, we still you know and there are different generations I think in Europe the European standard now there's probably like 4th generation waste to energy plants that they that they've got and you can probably get quite a bit of information about them of you to know of the net so that is the sort of standard that the that we're working off now and a lot of that's got to do a with the emissions that that they're trying to curtail #1 and #2 is the sort of. R2.*

Survey results showed that 29% of the respondents were neutral about the impacts of international relations. This agrees with opinions provided by R3 who feels that sometimes international communities may be interested in bankable projects such as RE, which might not benefit a large population of the communities. With this regard, municipalities must treat international relations with care to avoid deviating from their primary service delivery mandate. The same issue was touched by R7, who believe that some international communities may not be providing genuine support and sometimes impose policies which might not be locally suitable. In this regard, R7 suggested that municipalities should learn from international communities, adopt what suits their context and reject unsuitable superimposed policies.

> *Your traditional economic approaches, where they talk about bankable projects, I have a big fight with the …… and a lot of these call it international donor agencies where they come in and they look for bankable projects. And I tell them, if you come to, I'm gonna say Africa as a whole. Even in South Africa, while we might be kind of sitting in that middle-income bracket, this whole notion of bankable projects means you're shutting out 80% of the population R3.*

In literature, local municipalities may reach out to international organisations through platforms such as GIZ (WWF, 2015). However, R3 suggested that this can be done through international seminars and conferences, and even learning indirectly from local municipalities that a well connected to international partners. This is important for municipalities which do not have a plan or clue on how to engage with international partners as given by R6.

> *We are speaking about Australia, but how do I get hold of somebody who is in Australia if there is no engagement?*

8.7.8.8 Capacity building

Several aspects of capacity building studied during a survey included educational and learning investments, upskilling and reskilling staff. The results are reported in Figure 8.5. With regards to investing in education and learning, 25.9% strongly agreed, 49.5% agreed, 22.2% were neutral and 2.4% disagreed. Investing in education and learning, for example, by establishing renewable energy learning centres has previously been discussed as one of the best practices we can learn from countries such as the USA (Section 8.6). R7 argued that even if proper policies are put in place this is not likely to succeed if the skills are not there. Hence, the reskilling process can be achievable with close collaboration with universities.

> *Certainly, there's a need for reskilling and what I strongly advocate for is close collaboration between the municipalities and the universities R7.*

The other aspect is upskilling and reskilling of existing staff. From the study 17.3% strongly agreed, 34.6% agreed, 34.6% were neutral, 9.8% disagreed and 3.7% strongly disagreed. Based on key informant perspectives, upskilling of existing staff is needed since there is a shortage of skills (R1, R2, R3, R5, R6, R7). R6 argued that a new set of skills is needed for renewable energy while integrating with existing ones. The challenge is that their municipal structure does not allow for that. Giving an example of Durban as a reference point, the respondent mentioned the metro as having a separate energy department with its staff. Meaning the successful integration of new skills has budget and restructuring implications.

> *We will need a lot of skills and, our structure at the moment does not allow for that in such a way that even how Durban has done it, they've created a separate department to deal with the energy as such, renewable or not renewable, they created a department that recalls their Energy Department with the head of the department and separate engineers and electricians away from the reticulation team R6.*

The other thing is when the skills tobe developed are identified, there must be a need to develop that skill. It's not only about randomly upskilling.

> *So when you identify skills to develop, the person whose skill is supposed to be developed, but sees the need for that skill to be developed R7.*

8.7.9 Summary

The empirical findings highlighted various challenges that could hinder the successful implementation of renewable energy. While issues like land availability and tenure may not pose challenges if suitability for specific purposes is considered, social factors such as political turf wars, managerial attitudes, energy pricing and marketing, insufficient skills, grid

accessibility, and high infrastructure investment costs, alongside potential job losses in the fossil fuel sector, emerge as significant obstacles.

There are several approaches to address the challenges that have been identified. These approaches include implementing proper market research and tariff policies, fostering carbon taxes, public-private partnerships, community awareness and communication strategies, top management support, promoting effective change management, strengthening international relations and capacity building.

8.7.10 Recommendations

- Policies that integrate all political parties to work in harmony when addressing the renewable energy agenda should be implemented.
- Top management awareness campaigns and training should be enforced.
- Skills development programs should be specific by including relevant issues for specific staff from top management to the technical team.
- Provide training and reskilling opportunities for existing staff at all levels, including top management, middle management, and general workers.

9 GENERAL DESCRIPTION AND RECOMMENDATIONS FOR BEST STRATEGIES AND PRACTICES

9.1 Introduction

As the world navigates its way through the challenges posed by climate change, the role of the local government has been identified as pivotal to the integration of RE to achieve the global agenda of a green economy. In the same vein, the critical role of local government in the adaptation of RE to the South African system has been established in several sections of this study. Therefore, this study comprehensively integrated critically reviewed scholarly works and empirical studies through structured and semi-structured surveys to draw conclusions and recommendations on the identified shortfalls of local government concerning the promotion of renewable energy and its implications on skills development. The recommendations are carefully outlined below.

9.2 Policy recommendations

Stakeholders/ Other Resource Persons	Role of Stakeholders	Methodology of Operations
Policy recommendations on the role of local government in adapting to renewable energy		
• SACN (South African Cities Network) • SALGA • Local municipalities	**SACN:** Forming new strategic partnerships across cities. **SALGA:** To coordinate all local governments, provide training to top management on RE and coordinate participatory discussions on strategic integration of RE in IDPs. They also participate in policy lobbying and advocacy for mandatory RE implementation in all local governments. **Local governments:** Provide insights on their perspective towards RE, limitations to their implementation and their view on the future of RE. This provides an opportunity to co-develop a strategic RE implementation and integration into municipal IDP plans.	The LGSETA together with SACN and SALGA should work together in helping local municipalities co-develop holistic strategic plans that support renewable energy implementation and integrate them in their IDPs.
• SACN • SALGA • Eskom • The DMRE South African Renewable Energy Masterplan (SAREM) • Civil Society (e.g. PPGI)	**SACN:** Advocacy for urban sustainable development agenda. **SALGA:** Coordinate dialogues with relevant stakeholders (Eskom and PPGI) in the interest of local municipalities to co-finance rehabilitation of unutilised Eskom infrastructure. **Eskom:** To provide a consensus on leasing or establishing a memorandum of agreement with the local municipality to utilise infrastructure they are not able to repair, maintain and utilise as an urgent action stated in the SAREM. **Civil society:** To ensure that the infrastructural leasing or agreement policies between local governments, Eskom and private companies	Local municipalities should engage with SACN, SALGA, Eskom, IPPs, and the Department of Energy and Mineral Resources (DMRE) to develop clear policies on utilizing existing underutilized energy infrastructure to allow municipalities to integrate renewable energy from IPPs.

	(SMMEs) are done in an economically sustainable and equitable manner.	
Recommendations on municipalities' role in the field of RE production		
• Civil society (PPGI) • SALGA • SACN	**PPGI:** To build cooperation and collaboration between the private sector and government. **SALGA:** Provide support and advice on legal issues surrounding MOA signing to prevent fraudulent bidders. **SACN:** To stimulate and promote new partnerships with urban municipalities.	The local municipalities should collaborate with other surrounding municipalities and sign a memorandum of agreement (MOA) to provide markets for large-scale RE purchasing from IPPs.
Recommendations on skills required by the local government sector in promoting RE systems		
• LGSETA • SALGA • Local municipalities • Civil Societies (e.g. PPGI): • DBE (Department of Basic Education)	**LGSETA:** Regulate curriculums and content for training entrepreneurs on the importance of RE and its importance on current and future generations following local government standards. **SALGA:** Will coordinate local governments to provide training to entrepreneurs on RE. **Local municipalities:** Mobilise their community liaison department, and coordinate community outreach programs focusing on RE. **DBE:** Authorising contact with schools on community technological demonstration. **Civil Societies:** Engage with communities, educate them about the impacts of conventional energy sources, and promote sustainable and cleaner energy sources through community outreach programs and other platforms such as churches.	Local municipalities should work with LGSETA and SALGA in developing training manuals focused on top managers where they will spread awareness about the importance of RE on the environment, potential contribution to community development, revenue flows and current and future energy security. For example, the importance of waste to energy on direct benefits such as energy security, and indirect benefits on the environment e.g. reduced greenhouse gas emissions and lengthening the landfill lifespan. The local municipalities should engage LGSETA, SALGA, civil society and socially disadvantaged entrepreneurs about potential business opportunities around RE e.g. rooftop solar installations and maintenance. Local municipalities should collaborate with the Department of Education to install demonstration technologies that can be used by school children and communities to learn and understand RE.

• SALGA • LGSETA • EWSETA • DIET • DBE • DSI • DTIC • DYWPD • Local municipality • SALGA • COGTA • Networks (e.g. climate change adaptation network; CCAN)	**SALGA:** Capacity building in local municipalities to train communities, and engage with relevant stakeholders in different knowledge-sharing platforms. **LGSETA and EWSETA:** Regulate curriculums and content for training local municipality top management and staff according to local government and renewable energy field standards. **DHET and DBE:** Curriculum development for tertiary students and schools respectively following RE industrial demands. To foster community Education and Training **DSI:** To finance capacity building through university scholarships and research students. **Local municipality:** Local government resources including staff, land and energy by-laws. **SALGA:** Coordinate local municipalities in capacity building and advocacy. **DYWPD:** Mobilise and finance to support capacity building for socially disadvantaged groups. **Networks:** Promote knowledge sharing and partnerships on adaptation to climate change across stakeholder groups	The SALGA and LGSETA should establish coordinated policies to integrate common RE training and information-sharing grounds across all local municipalities. LGSETA and SALGA should work together with local municipalities to spread awareness to strategic management on budgeting for RE research and development in collaboration with academic institutions. LGSETA, SALGA, EWSETA, Department of Higher and Tertiary Education (DHET), Department of Education, private sector and DSI should engage, discuss and develop a practical RE curriculum which contains technical RE skills that are absorbable in the industry. Local municipalities in collaboration with DYWPD, DHET or TVET colleges and LGSETA should develop guides for training small-scale entrepreneurs which is imperative for the community development sector.
Recommendations for technical, economic, and environmental feasibility of supporting households and economic entities with implementing RE systems		
• SALGA • DFFE (NEMA) • Civil society (PPGI)	**SALGA:** Advocacy for policies on waste-to-energy projects on behalf of local government.	The municipal waste management units in the local government should work with DFFE to develop policies to allow private sector access to organic feedstock from landfills

• DALRRD • NGO (e.g. Greencape) • Academia (e.g. UKZN/RUNRES)	**DFFE:** Guide on environmental impact assessments and organic waste management following the NEMA and National Waste Management Strategy **PPGI:** To mobilise local communities and farmers to participate in the agricultural use of organic fertilisers. **DALRRD:** To regulate standards for organic fertilizer, provide extension services and farmer mobilization. **Academia and NGOs:** Facilitate transdisciplinary approach in the promotion of upscaling of green technologies.	and wastewater treatment plants for waste-to-energy generation. The local government should engage farmers, NGOs, the Department of Agriculture Land Reform and Rural Development (DALRRD) the fertiliser regulator and entrepreneurs to establish policies for the production, selling and utilisation of organic compost made from organic waste.
• SALGA • COGTA • Local municipalities • NGO (e.g. Greencape) • Academia (e.g. CSIR, UKZN/RUNRES) • Civil societies (e.g. PPGI) • DSI, NRF • Private sector • CGCSA (Consumer Goods Council of South Africa) • SSEG	**SALGA:** To coordinate all local governments and promote capacity building and policy advocacy. **COGTA:** Coordinate governmental departments and influential stakeholders such as traditional leadership to link with academia for coherent research, development and implementation. **NGOs and Academia:** Facilitate transdisciplinary approach in the promotion development, testing, improvement and upscaling of green technologies. **Civil societies:** To mobilise community participation for participatory and inclusive research and development. **DSI and NRF:** Research and development funding, policy briefs and advocacy. **Private sector:** Provide experience and cofinance in research and development for waste-to-energy solutions.	The local municipalities should engage SALGA, COGTA, scientific experts (e.g. CSIR and Universities), the Department of Science and Innovation (DSI), traditional leadership, entrepreneurs and community champions to contextualize potential renewable energy options for specific municipalities, co-identify and co-test selected technologies, generate sustainable context-specific business models and scale out or recommend feasible technologies. All the research and innovation tools should be mobilised through transdisciplinary research participated by national research institutions such as DSI, CSIR and Centre for Renewable Energy Research, academic institutions such as Universities to provide students, successful private companies to provide practical experience and expertise, SALGA and COGTA to link up with local municipalities, local communities (community champions, traditional leadership, schools) to provide insights from the community perspective, the DBE to link with schools as demonstration sites, the DALRRD to map available land resources and negotiate with traditional leadership on tenure issues, Civil Societies

	CGCSA: Quality control through establishing standards and norms to protect consumers, regulatory advice and advocacy, sustainability guidance and advisory and engagement with government departments and regulatory agencies. **SSEG:** Guidance regarding municipal SSEG regulations, processes, tariffs and application processes.	(Churches) to mobilize communities and the CGCSA to advocate for standards and norms. Research should be centred around technology improvement, local and international market research, context studies (waste streams mapping, legal and policy analysis, social perceptions and value chain analysis) and piloting scalable models. The COGTA and SALGA should establish policies to monitor and report on the enforcement of standards which involve public consultation in all activities and accountability of top management.
Recommendations from international and regional best practices for implementing sustainable RE systems		
• DMRE • DTIC (e.g. Trade and Investment KZN) • Civil society (PPGI) • CGCSA	**DMRE:** Provides strategic tools to implement renewable energy policies. **DTIC:** Facilitates industrial and commercial policies towards renewable energy business and trade. **Civil society:** Represents the needs of SMMEs in the energy value chain. **CGCSA:** Quality control through establishing standards and norms to protect consumers, regulatory advice and advocacy, sustainability guidance and advisory and engagement with government departments and regulatory agencies.	Local municipalities should engage the DTIC, DMRE, Eskom, SSEG and IPP to draft a strategic plan that will allow local municipalities to independently implement their energy policies. Local municipalities should engage with the COGTA, National Treasury, DTIC and IPPs to establish RE subsidy and pricing policies to ensure equitable energy access while maintaining the sustainability of private energy companies. Local municipalities should engage with the National Treasury and the Department of Foreign Affairs to develop RE policies that promote and effectively support well-defined, comprehensive and equitable RE co-financing policies with foreign investors. The local municipalities should engage the National government: DHET and National Treasury through SALGA to

		mobilise their public works departments to work towards establishing RE centres even at the provincial level.
• SALGA • COGTA • DFFE • DHET • NGOs (e.g. GreenCape) • Knowledge platforms (C40) • CGSA • DTIC	**SALGA:** To coordinate all local governments and promote policy advocacy. **DHET:** Finance the construction of a public academic renewable energy centre **DFFE:** Ensure that reasonable legislative and other measures are developed, implemented and maintained in such a way as to protect and defend the right of all to air and atmospheric quality that is not harmful to health and well-being. **Knowledge platforms and NGOs:** RE knowledge repository and sharing centre; policy briefs, state of art best practices and approaches, **CGCSA:** Quality control through establishing standards and norms to protect consumers, regulatory advice and advocacy, sustainability guidance and advisory and engagement with government departments and regulatory agencies. **DTIC:** To improve the competitiveness of actors across RE value chains at local and international markets.	The local municipalities should engage the National government: DHET and National Treasury through SALGA to mobilise their public works departments to work towards establishing RE centres even at the provincial level. The local municipalities should engage SALGA and COGTA/CGCSA for the mobilisation of National Government departments such as DFFE to develop and enforce policies against C footprint in all local municipalities. These should include strategic plans for incentives such as C credits, tax exemptions on green energy and lower or no interest for loans around RE in agreement with microfinance and the National Treasury. The local municipalities should work with COGTA, SALGA, LGSETA, civil society groups and DTIC to establish policies that harmonise local municipalities and provide responsibilities across the RE value chain in a way that directly and indirectly improves the livelihoods of people in each local municipality.
Recommendations for challenges the South African local government can face in promoting RE systems		
• COGTA • Civil society (PPGI) • DALRRD	**COGTA:** Coordinate governmental departments and influential stakeholders such as traditional leadership to link with local governments. **Civil societies:** To mobilise community participation for participatory and inclusive consultation.	The local municipalities should engage traditional authorities through COGTA and DALRRD in allocating land for RE to avoid local disputes. Secondly, the public relations of local municipalities should engage with security services (SAPS) and local communities through outreach programs, school activities such as

		sporting events or competitions, community demonstration projects and educate communities about the benefits of RE in their area. This creates a sense of ownership amongst communities, eases social issues such as infrastructural vandalism and creates a conducive work environment to attract large-scale investments. Local municipalities should establish policies to provide long-term lease agreements for large-scale RE investors that will play a significant development impact on the communities.

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