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RECEIVED 08 November 2024

ACCEPTED 14 February 2025

PUBLISHED 12 March 2025

## CITATION

Oladejo OM, Shava E and Ndebele NC (2025)  
Renewable energy adoption: a case of skill  
gaps in South African local government.  
*Front. Sustain. Energy Policy* 4:1525160.  
doi: 10.3389/fsuep.2025.1525160

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# Renewable energy adoption: a case of skill gaps in South African local government

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The transition toward renewable energy systems is crucial in addressing the global challenge of climate change and reducing reliance on fossil fuels. Local governments play a pivotal role in driving this transition. As an arm of government closest to the grassroots, local governments are uniquely positioned to influence energy consumption patterns and ensure sustainable practices through local policies and regulations. Unlike federal initiatives that often focus on broad policy frameworks, local governments operate at the grassroots level, enabling them to influence energy policy directly, engage community stakeholders, and drive the implementation of renewable projects. However, to effectively promote renewable energy systems requires diverse skills among local government officials and staff. These include technical, policy formulation and regulation, finance management, etc. To understand the skills that will benefit renewable energy solutions within the communities, the study adopted a qualitative research methodology, which utilized face-to-face interviews guided by a semi-structured interview framework. Seven (7) stakeholders from South Africa's renewable energy sector were purposively selected to respond to interview questions. Data was collected using MS Teams, where it was recorded and later transcribed to Microsoft Word. Thematic analysis was applied to observe and understand the patterns in the data. The study results revealed that officials from selected local municipalities demonstrated a significant lack of necessary renewable energy skills, which triggers poor adoption of renewable energy and its implementation at the local government level. This underscored the ineffective renewable energy policies at the grassroots level and portrayed the need to develop the required skills at the municipality level to harness the social and economic opportunities that could be derived from utilizing renewable energy in communities. The study's conclusions emphasize the need for local government staff to be exposed to renewable energy training that helps build capacity through synergy and inclusive participation to ensure a successful renewable energy transition.

## KEYWORDS

renewable energy, adoption, skill gap, local government, capacity development

## 1 Introduction

As the world grapples with energy and the complexity of finding clean energy sources, renewable energy (RE) is fast evolving as an alternative for central and local governments in Africa to leverage social and economic opportunities for the citizens. Contemporary and empirical analyses of the literature have demonstrated that the transition to green energy cannot succeed without the essential involvement of local governments, which are

the arm of the government closest to the grassroots (Chibambo et al., 2019; Kata et al., 2022; Mutereko et al., 2023). The collaboration of Local governments as a stakeholder is crucial at the grassroots level to help improve the governance of RE projects (van Staden, 2017). According to the author, such collaboration in the co-production of RE helps in pooling scarce human and financial resources together to ensure the successful implementation of RE projects. Wolman (1995) characterizes local government as an arm of government tasked with delivering services that meet the community's needs at a reasonable cost. Furthermore, local government serves as a political institution grounded in democratic principles. Drawing from Bains (1972) and Jones and Stewart (2012) argue that local government is responsible for the overall economic, cultural, and physical wellbeing of the communities within its domain.

South Africa is a major coal producer (seventh globally), using it to generate ~77% of its electricity. However, the over-reliance on coal causes significant environmental harm, giving the nation the highest per capita greenhouse gas emissions in Africa. Despite this, some rural areas still lack electricity access (Jain and Jain, 2017). According to the authors, South Africa's RE potential is globally significant. Its solar resources are among the best in the world, evidenced by the average of 2,500 h of sunshine and 4.5 to 6.6 kWh/m<sup>2</sup> of solar radiation received each year. In addition, the country holds an estimated 670,000 GW of wind power potential, a resource comparable in scale to its solar endowments. Although the nation has made significant progress in RE to increase its share of RE in the electricity mix to 49% by 2,030. Renewables account for around 9% of the country's total final energy consumption, with solar and wind power being the primary sources. The government has implemented various initiatives to promote RE, including the Renewable Energy Independent Power Producer Procurement (REIPPP) program, which has attracted significant investment in the sector. In terms of trends, South Africa's RE sector is expected to continue growing, driven by declining technology costs and increasing demand for clean energy. The country's Integrated Resource Plan aims to reduce greenhouse gas emissions and increase the share of renewables in the energy mix, with a focus on solar and wind power. Additionally, there is a growing trend toward embedded generation, which allows households and businesses to generate their RE and feed it back into the grid. Overall, South Africa's RE sector is poised for significant growth, driven by government policies, declining technology costs, and increasing demand for clean energy. With its abundant solar and wind resources, the country has the potential to become a leader in RE in Africa.

In the same vein, in South Africa, the Constitution places significant obligations on local governments to provide basic services (Republic of South African Constitution, 1996). However, due to the unique challenges presented by the shift from traditional energy sources, there is a need for specialized skills and capacities. Adopting RE at the local government level is crucial, as studies have shown that local initiatives significantly contribute to energy diversification and have shaped energy policies in nations like Denmark, Germany, and the UK (Mey et al., 2016). Unfortunately, many South African local Governments face gaps in RE skills. Therefore, it is essential to develop these skills through new ones.

vocational training, curricula, and educational programs aimed at upskilling and reskilling the existing workforce at the municipal level (International Energy Agency, 2022).

A global assessment by the International Energy Agency (International Energy Agency, 2022) has highlighted an anticipated rise in jobs related to green energy, projecting the sector to generate around 14 million jobs and train over 30 million individuals from traditional energy backgrounds. At present, the capacity of human resources to facilitate the transition to RE is hindered by inadequate labor structures, limited interest in RE investments, and difficulties in attracting qualified personnel (Adewumi, 2022; Todd and McCauley, 2021). These skill gaps have attracted the attention of scholars in public governance. For instance, Malamatenios (2016) points out the employment and economic development opportunities associated with the transition to RE. Yet, a rising unemployment trend was highlighted and linked to a deficit in RE skills. Additionally, Zekaria and Chitchyan (2019) investigated the knowledge landscape within the national government's energy framework, revealing a significant deficiency in policy comprehension and expertise concerning RE. In another study, Fouché and Brent (2019) explored the local government's approach to RE for sustainable development. The action research and cognitive mapping revealed that at the local government level, RE initiatives are often considered from a project standpoint rather than integrated into a broader municipal strategy.

Despite these studies, there is a notable dearth of studies on the specific RE skills necessary at the municipal level for a successful energy transition. Current literature fails to provide a thorough and detailed analysis of the RE skills and training available to local government staff, leading to an insufficient understanding of these skills. This gap in comprehensive scholarly literature leaves local government practitioners and policymakers without a solid foundation for making informed, evidence-based decisions, relying instead on speculation or conjecture. As a result, resources and time may be wasted on training initiatives grounded in anecdotal evidence rather than tangible needs. This study, therefore, seeks to identify and delineate the skills required for local governments to effectively transition to RE in South Africa.

The structure of this study is as follows: Section 2 assesses the skills necessary for local governments to adopt RE. Section 3 addresses capacity building within local municipalities, while the subsequent section explores engagement with the stakeholders, including communities, academic institutions, and the private sector, regarding skills requirements. Section 4 offers recommendations for skill development through upskilling and reskilling initiatives, curriculum reforms, and collaboration with the international community.

## 2 Literature review

This section examines scholarly literature on RE skill development needed for RE transitioning at the Local government level. The study emphasizes the importance of RE skill development at the local government. The concepts of RE skill development have emerged as vital subjects in the study of RE and sustainability. As the world faces climate change issues and its attendant

TABLE 1 Capacity building for local governments to transition toward RE.

Capacity building	Reference
Technical training	(eThekweni municipality, 2020; Mbazima et al., 2022).
Skills required	Reference
Policy and political barriers	(Todd and McCauley, 2021; Apfel et al., 2021; Nel, 2015; Averchenkova et al., 2019)
Limited financial resources	(Todd and McCauley, 2021; 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	(eThekweni municipality, 2020; Weinand et al., 2019)
Infrastructure, Intermittence, storage and grid constraints	(Madumo, 2015; Aliyu et al., 2018)
Bureaucracy	(Todd and McCauley, 2021; Nel, 2015)
Resource dependency	(Apfel et al., 2021)
Lack of public awareness	(Nel, 2015)

consequences, the promotion of RE systems has gained prominence across various levels of government. Local governments, often seen as the frontline of environmental policy implementation, are uniquely positioned to stimulate the adoption of RE technologies. Hence, developing RE skills at the grassroots is recognized as an essential component for building a sustainable future.

## 2.1 Assessment of skills needs

Collaborating with stakeholders allows local municipalities to assess existing and future skills for the RE sector. Skill assessment includes the identification of skills gaps, understanding the demand for various roles, and understanding the need for technological improvement. This section assesses the skills needed for RE capacity building at the local government level. In addition, the skills required were identified based on challenges the South African local municipalities face with implementing RE (see Table 1). 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).

### 2.1.1 Capacity building

Capacity building refers to the process of developing and strengthening the skills, competencies, and abilities of individuals and organizations (World Health Organization, 2001). In the context of RE in South African local governments, it encompasses various aspects, including technical training, policy and regulation

development, financial management, and knowledge sharing. The primary goal is to equip individuals and organizations with the necessary tools and knowledge to thrive in a rapidly evolving energy landscape.

#### 2.1.1.1 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 (eThekweni municipality, 2020; Mbazima et al., 2022), energy storage and grid integration (DMRE, 2019; eThekweni municipality, 2020; Thango and 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 can be utilized 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 needs 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. eThekweni 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 becomes a problem. For example, solar water heaters imported from South Africa failed due to a lack of maintenance and inadequate skills (Akinbami et al., 2021).

## 2.1.2 Skills required

### 2.1.2.1 Policy and regulation

Capacity building can be applied to the management level. Some policy barriers may impede local municipalities from implementing RE and these need to be addressed (Apfel et al., 2021). Policy change is a complex process requiring high engagement levels 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 toward 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 at a high level. Thus, a 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.

### 2.1.2.2 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, 2019; Heidari and Heravi, 2023). There are two common funding sources: private and public sector funding (Heidari and Heravi, 2023). Funding can be obtained from local microfinance companies and even international organizations such as the World Bank (Todd and McCauley, 2021). Thus, stakeholder engagement skills are needed to leverage funding opportunities from public and private institutions and companies. Local municipalities need financial and economic modeling 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.

### 2.1.2.3 Creating a knowledge-sharing platform

Municipal officials can meet and share experiences in RE on various platforms. 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.

### 2.1.3 Partnerships and collaboration

Developing technical, legal and business skills to engage with IPPs is imperative. SALGA (2021) advocates for action toward 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 toward developing 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 upskilling 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 organizations 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 enroll;
- 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.

#### 2.1.3.1 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 (2019) 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 organizations that local municipalities can work with to upskill their staff. The GIZ is one of the Germany-based organizations that provide training and skills programs for local municipalities to transition more easily toward RE, and they are actively working with SALGA (South African Local Government Association; 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 (DFPE), 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 organization with significant experience in capacity building (Lucas et al., 2017).

### 2.1.3.2 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 (Godfrey et al., 2020; Mbazima et al., 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 centers 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 (2019) 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).

### 2.1.3.3 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, 2019). 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 labor markets (DMRE, 2019). 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 developing current and future skills (DMRE, 2019). In addition, industries can support internship programs to promote the university-industrial linkage. For example, the 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).

### 2.1.3.4 Inclusive training

The energy transition process must prioritize the welfare of communities from marginalized areas, including those impacted by RE initiatives, such as coal production towns. The REIPPPP

was initiated to align with the NDP, focusing 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 by Nkoana (2018) revealed that involving IPP is selective; it favors 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 livelihoods for local communities to RE might come with job losses, which should be avoided, as trade unions advocate.

With that in mind, training local communities to maintain and repair 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 maximize 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, 2019). 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 youth participation by 2030 (DMRE, 2019). Jeffreys Bay Wind Farm has played a pivotal role in community development in South Africa. This was done through enterprises that support emerging black-owned companies in 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 the 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 prioritizes vulnerable stakeholders as a long-term solution.

### 2.1.4 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. However, local communities often perceive these 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 labor 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. Since 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).

Previous scholarly studies have identified several skills such as technical, policy regulation, finance management etc., as some of the skills lacking at the local government level. 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 explores the role of the local government sector in promoting RE and its implication on skill development. The following research questions were developed to address the above research gap. What is the role of local government in adapting to RE? and What skills are required by the local government sector to promote RE systems?

## 2.2 International best practices a case of Germany and Japan

This section explores the intricate relationship between national policies and local initiatives in enhancing energy transitions, using Germany and Japan as contrasting case studies. Although Germany's federal structure empowers local governments, particularly municipal enterprises in the energy sector, their autonomy is limited. While the Constitution grants them some independence, these entities primarily function as extensions of state and federal administrations (Kuhlmann et al., 2021). According to the authors, the scope of this autonomy is restricted by regulations enacted at the state level, resulting in variations in the precise extent of this right across individual federal states. This dependence often leads to financial instability, requiring reliance on higher-level government support. Furthermore, despite providing essential energy services, state regulations restrict these municipal energy companies' administrative and entrepreneurial freedom.

Unlike Germany, Japan features a highly centralized energy system. Powerful established utilities, supported by the Ministry of Economy, Trade, and Industry (METI), resist decentralization initiatives, citing concerns about grid compatibility. The significant control over transmission and distribution effectively restricts local energy access. However, growing public opposition to

nuclear power, increased municipal involvement in energy generation and distribution, and electricity market deregulation created opportunities for local environmental groups. These groups challenged the dominant utility model by promoting local electricity retailing initiatives. The contrasting dynamics in Germany and Japan illustrate how national policies and grassroots efforts influence energy transitions (Hager and Hamagami, 2020). Understanding the political landscape surrounding these transitions, especially the role of local authority, is critical.

Several studies prioritize policy as the primary driver of innovation, potentially overlooking the agency of local actors and framing them as passive recipients of policy choices, focusing on factors that encourage or restrict local acceptance (Jordan and Matt, 2014; Maruyama et al., 2007; Musall and Kuik, 2011). Unlike studies prioritizing national policy's impact on local actions, grassroots activism is essential as a key driver of RE adoption. Local communities often first recognize the economic and demographic advantages of RE investment, ensuring a "socio-political space" for its development and safeguarding support for RE policies. Therefore, given the urgency of addressing the global climate crisis, understanding these local-national dynamics is essential for crafting effective policies that create positive feedback (Jordan and Matt, 2014; Levin et al., 2012).

Given the experiences of Germany and Japan, there is a significant need to emphasize the role of local authority in RE adoption. Recognizing the economic and demographic benefits of RE investment often comes first at the local level (Musall and Kuik, 2011), ultimately playing a crucial role in creating the necessary "socio-political space" for RE technology development (Lauber and Jacobsson, 2016, p. 148) and stabilizing national energy transitions to prevent the undoing of low-carbon policies. As Rosenbloom et al. (2019) argue, such stabilization requires integrating the transition into society by ensuring a supportive "ecosystem" of grassroots authority and private organizations.

## 2.3 Theoretical perspective: human capital theory

This study adopts the Human Capital Theory (HCT), which is described as the process of acquiring skills, knowledge, intelligence, and competencies through education or training (Bae and Patterson, 2014). Extensive research highlights the significance of HCT in driving economic growth and development at the individual, organization, and national levels (Bae and Patterson, 2014; Lauder, 2015; Ekanem, 2014). HCT underscores the necessity of quality education and training in today's global economy. For education or training to meet these demands, it must adhere to high standards, aligning with both expectations and international benchmarks. Consequently, the objective of having a sustainable RE sector at the local government level in South Africa requires RE-trained personnel. Hence, the RE sector at the local government level requires quality training to develop and enhance the human resources vital for RE socio-economic advancement and to maintain a competitive edge.

This study draws upon the foundational work of Schultz (1961), Becker (1964) regarding HCT, alongside Tan's (2014) recent

insights, to highlight the crucial role of training in enhancing the skill and performance of personnel at the local government in South Africa on RE. HCT emphasizes the benefits of education or training in improving skills, knowledge, and competence, advocating for investments in training that yield productivity and socio-economic returns that are particularly relevant to this study. Furthermore, it prompts an exploration of how training can influence the skills, performance and productivity of local government personnel in RE. This investigation is driven by the need to ascertain whether training genuinely enhances local government personnel, as originally posited by [Schultz \(1961\)](#); [Becker \(1964\)](#) and later supported by [Tan \(2014\)](#).

Despite its foundational role, HCT has faced substantial critique since its inception. Tan provides a comprehensive analysis consolidating various criticisms of HCT ([Tan, 2014](#)). One significant point of contention is the theory's relationship with other frameworks, particularly the signaling theory proposed by [Spence \(1974\)](#), which posits that education or training primarily indicates an individual's intelligence and learning abilities. Schools use grades and examinations to categorize students, while HCT asserts that education or training directly improves knowledge and skills, thus leading to increased productivity and higher wages. However, this position is often challenged, as academic performance has not always accurately reflected a person's true capabilities; many individuals have excelled in their careers despite poor academic performance. However, despite this criticism, the study relies on the justification of HCT that education and training can enhance the performance of local government personnel in South Africa's RE sector. To this end, HCT helps in understanding the contribution and benefits that investment in training for local government personnel potent especially for RE sector.

### 3 Materials and methods

This study investigates RE skills required at the local government level for a successful transition to RE in South Africa. Using a qualitative methodology, the study sought to obtain in-depth insights into the perspectives of key stakeholders in the RE sector at the local government level regarding RE skill development. Semi-structured interviews were conducted to elicit a comprehensive understanding of the subject matter. A purposive sampling technique was utilized to select stakeholders identified through a social network approach. The qualitative data obtained from these interviews were analyzed using thematic analysis, which allowed for the identification of recurring trends and patterns in the data ([Figure 1](#)). The study reflects the experiences and viewpoints of the stakeholders who were interviewed to elicit their insights on RE skill development at the local government level. These stakeholders include 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). Purposive/Judgmental sampling method was used to recruit the participants. This method allowed the authors to use their discretion in choosing those who could provide relevant information on the subject of investigation based on their positions. The insights derived from these stakeholders illustrate their diverse

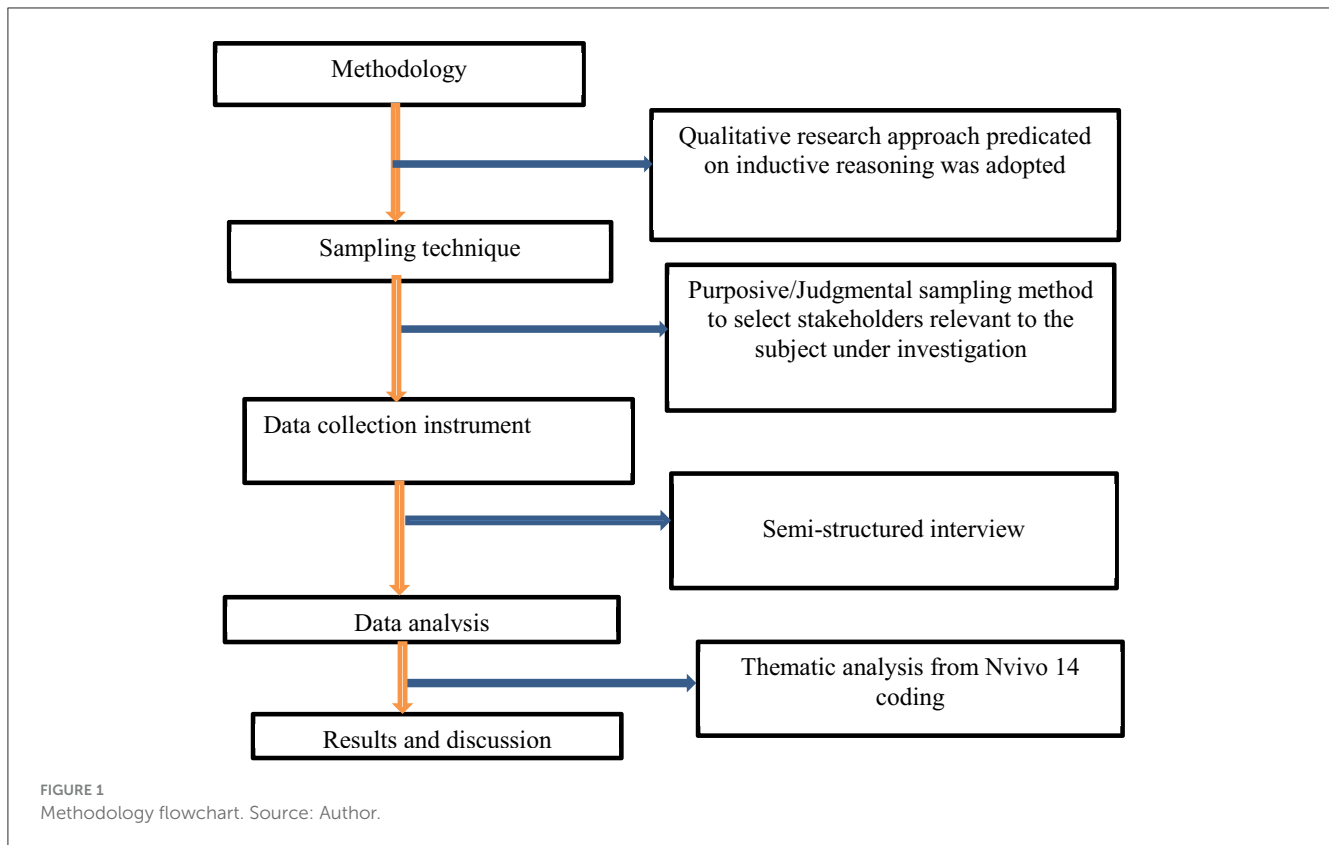
views on RE skill development at the local government level. Each interview lasted ~30–40 min, was recorded with participants' consent and subsequently transcribed for analysis. This method provided both flexibility and consistency in data collection across all interviews. By focusing on individuals with direct experience and expertise in the RE sector, the study aimed to gather rich and valuable data that offers a comprehensive understanding of addressing the RE skill gap at the local government level in South Africa, thus enhancing the credibility of the study's findings. For ethical considerations and efficient theme analysis, pseudonyms such as R1, R2, and so on were employed to facilitate the tracking of results to specific municipalities and respondents.

### 3.1 Research participants

This study adopts in-depth, face-to-face interviews to collect rich, non-numerical data from the seven (7) stakeholders in the RE sector at the local government level. The participants comprised three (3) municipalities, three (3) academic and research institutions, and one renewable energy company, all selected purposively due to their significant roles in the RE sector. The interviews were held in some of the participant's respective offices to create a relaxed and comfortable atmosphere and were done via MS Teams, where it was recorded and later transcribed to Microsoft Word. Prior to each interview, the study's purpose and ethical considerations (including anonymity, confidentiality, and informed consent), along with the interview guide, were thoroughly explained. The interview guide was carefully developed to ensure that all relevant information needed to achieve the study's objectives was captured, thereby safeguarding data integrity and accuracy. Additionally, observation notes were recorded during data collection to maintain a comprehensive account of the interviews. The semi-structured interview guide aimed to facilitate a deeper exploration of the participants' perspectives on the RE skills gap at the local government level, addressing how to bridge the development gap in South Africa.

#### 3.1.1 Sample

Although the sample size was limited to seven participants, saturation was nonetheless achieved. According to existing literature, saturation typically occurs with sample sizes ranging from 5 to 30 in single-case and phenomena studies ([Guest et al., 2006](#); [Creswell, 1994, 225](#); [Kuzel, 1992, p. 41](#); [Morse, 1994, p. 225](#)). The purposive sampling method used was advantageous, enabling researchers to collect rich data and develop a comprehensive understanding of the participants' experiences. This understanding provided insights into the importance of RE skill development at the local government level in South Africa. By adopting purposive sampling, the study captured the authentic experiences of stakeholders regarding the local government's responsibilities in supporting RE skill training. A qualitative research approach was selected as it facilitated an in-depth exploration of the participants' experiences related to the phenomenon under investigation ([Anso, 2014](#)). This approach allowed the study to examine participants' perspectives on RE skill development at the local government level,



yielding valuable insights into how local governance can effectively enhance personnel skill training, especially in the RE sector.

### 3.2 Data analysis

Data analysis is a process of coding, transcribing, editing, and verifying data (Atiku et al., 2024). This study utilized thematic analysis, which involves condensing raw data into manageable segments to uncover patterns and trends (Blumberg et al., 2014). The audio recordings of the interviews were transcribed word-for-word and organized into themes according to their content to reduce bias (Kaupa and Olusegun Atiku, 2020; Steinke, 2004). In addition, the authors conducted independent coding, which was subsequently verified by an external qualitative researcher to ensure accuracy, consistency, and objectivity. Initial themes were discussed and refined until a consensus was reached, with further validation provided by the external investigator. The thematic analysis was conducted using NVivo 14 (Ganiyu and Genty, 2022; Atiku et al., 2024). Transcribed data from Microsoft Word documents were imported, and the software was used to organize the qualitative data into a hierarchical structure of themes. NVivo's node functionality aided in identifying and representing recurring patterns. These emerged themes were then contextualized by comparing them to established trends in the literature and further interpreted within the researchers' experiential framework (Bell et al., 2022). The use of NVivo 14 was crucial for the systematic identification, analysis, and interpretation of qualitative data patterns, thereby ensuring a comprehensive thematic analysis.

## 4 Result and discussion

The participants' views on the RE skill development at the local government level in South Africa were salient to this study, as such, interviews were conducted. Human Capital Theory was also used to showcase the importance of education and training for acquiring skills, knowledge, intelligence, and competencies. The thematic analysis generated three (3) themes, highlighting RE skills required by the local government. The themes include staff exposure to RE training and networking, synergy with academic institutions, and inclusive community engagement for RE participation. The following subsection delves into a discussion of these themes.

### 4.1 Staff exposure to renewable energy training and networking programs

This theme emerged as one of the riddles to solving the skills challenges in the transition to RE at the local government level. Findings from the analyzed data revealed that there are networking programs and training platforms in South African municipalities for staff to support RE and climate-smart technologies. Unfortunately, these platforms and programs are neglected by most of the municipalities. Almost all the participants confirmed this. For instance, some of the participants emphasized that their municipalities are part of the South African Cities Network, but they have not been actively discussing the idea of a RE agenda. This confirms the survey of DMRE (2019) that shows that 45.6% of the municipalities are largely involved in the South



African Cities Network, where RE issues are discussed. Some of the participants also confirmed the view that the DMRE (Department of Mineral Resources and Energy) 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 RE. One of the participants' views is shown below:

*Several municipalities, such as Nelson Mandela Metropolitan Municipality, Ilembe District Municipality, Richards Bay and eThekweni Metropolitan Municipalities, are at the advanced stages of RE implementation (R4).*

The response above shows that the platform for RE information sharing does exist. However, municipalities are not taking advantage of it. These collaborative platforms are potential training grounds for the staff of the municipalities. Staff exposure and training is an important aspects of driving the RE agenda. According to some participants, training should focus on different actors within the local municipality organogram. At the top management level, there is a lack of knowledge and exposure to the importance of RE as a revenue generation stream, solution to energy security, and sustainable energy form for current and future generations. Several participants raised a lack of priority as one of the problems associated with the top management. The reaction of one of the participants is captured below.

*The lack of interest by rural decision-makers in implementing energy initiatives is a problem. Local governments set up development targets in their IDPs where RE is not prioritized due to their attitudes toward conventional activities, which could include industry or existing operational methods (R1).*

This challenge is noted to be rampant as communities tried to submit proposals for a RE project in their local municipalities. Most of these proposals were not given attention, and no response was received. In many cases, this has been linked to a lack of in-depth understanding of RE operations. This type of response implies that strategic development skills are required in some of the local municipalities. Another participant who admitted the absence of RE projects in the municipality stressed this revelation further. The participant's view is shown below.

*In my municipality, no project is available at the moment besides the proposal that has been made. 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. RE is coming up with new areas such as manufacturing, installation, generation, wheeling and marketing. The required skill sets include engineering, encompassing design, installation and maintenance (R1). Soft skills are also required, including data

capturing, which individuals do with at least a matric certification. However, some of the participants argued that these skills are not relevant to the local government but can be applied by the private sector, which is doing the project. Another participant emphasized that they do not have any of the skills required in the RE space but mentioned the need for a consultant. However, the local municipality should be a catalyst to drive activities within its area of jurisdiction but not extensively involved in operations on the ground. Furthermore, the findings revealed that staff training could be needed for administrative activities like marketing, finance, and public relations.

*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. Some of the participants emphasized the advantages available within local municipalities to operate profitably if they can mobilize 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. These findings agree with Melica et al. (2018) submission of a multilevel governance, support, participation, and policy for RE. In this regard, SALGA plays a role in coordinating strategic planning training in alignment with the national development agenda.

## 4.2 Synergy with academic institutions

This theme was generated to provide insight into the required skills for a successful RE transition at the local government level. As engineering skills are crucial in the RE transition process, research and innovation also play a critical role in selecting the best and most adaptable technologies that are easy to operate, environmentally sustainable, socially acceptable, and economically viable. As such, academic institutions play a critical role. Universities are the hubs for knowledge creation and technology transfer, while local municipalities are technology implementers in conjunction with the private sector. Hence, the local governments need innovative synergy with academic institutions to support pilot projects and training for staff, unemployed youth and informal technicians. The findings of this study emphasized the willingness of some of the municipalities to synergise with academic institutions in their RE agenda. Furthermore, the analyzed data revealed plans to engage the local university in the RE space for a long relationship in research and collaboration. For instance, the research memorandum of understanding of Nelson Mandela University with some municipalities dates as far back as 2008. Along the way, numerous master's students developed various technologies, amongst others, best-performing solar panels. One of the participants expresses this.

*I think when we started we had a close relationship with the Nelson Mandela University. So we worked closely on a couple of other ways of collaboration and that's why we implemented it. In 2008, we did the first pilot on Went Small Went which was the House where I went batteries and PV panels. 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).*

In addition to the engineering skills, one participant highlighted the technology optimisation issue and the importance of academic institutions in driving that aspect. Academic institutions may not directly provide skilled labor in the municipality's RE sector, as issues such as budget constraints come into play. However, there must be mechanisms by which these skills are absorbed into the labor pool. One of the points of emphasis in the findings is that much of the work necessary for RE is locked in academia, which has not been implemented. The findings further showed that synergy with the academic institutions will complement the idea of staff upskilling or reskilling and the implementation of training programs where these ideas are not being implemented. Hence, universities may act as technology research, development and transfer centers while vocational centers focus on technical skills development. This finding aligns with Lerman et al.'s (2021) *triple helix (Th) model*, where partnership between government, university and industry was recommended for a successful RE transition.

### 4.3 Inclusive community engagement for renewable energy participation

Equitable access to energy should consider the indigent groups and communities. This forms part of the municipal responsibility as enshrined in the [Municipal Systems Act \(2000\)](#). One of the findings of this study revealed that 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. This finding agrees with [Bishoge et al. \(2020\)](#) submission that community inclusion is necessary for RE transition success. One of the participants expressed concern about the lack of community involvement, identifying it as a major drawback in the RE discourse. Additionally, the participants highlighted issues such as cable and electricity theft as hindrances in the energy sector, emphasizing 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. This view is captured below.

*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, channeled at treated as though they don't know what they want R2.*

Hence, the municipal liaison department is crucial in leading community engagement efforts and awareness campaigns in the renewable energy (RE) sphere. However, the participants indicated that although their local municipality has a community liaison department, the staff lack training on RE. 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.

## 5 Practical implications

This study explores the skills required by local government for successful transitioning to RE. It significantly expands knowledge on the RE skill gap at the local government level, providing valuable insights into the interplay between RE adoption and RE skill development at the local government level. The study offers evidence-based guidance for top management in local government in South Africa, enabling them to develop RE skill development policies. It sheds light on the role of RE training and collaboration in creating a positive RE adoption at the local government level. For instance, since the existing education and training system does not adequately prepare graduates with the specialized skills required for the RE sector and curriculum development often lags behind technological advancements, then, Local authorities must partner with universities, vocational training institutions, and industry to develop relevant RE curricula and training programs tailored to local government needs. Also, skilled professionals often migrate to the private sector or internationally, seeking better remuneration and career advancement opportunities. Governments must offer competitive salaries, benefits, and career development opportunities to attract and retain skilled professionals within local government. In addition, targeted training programs for local government employees that focus on technical skills, project management, financial management, and community engagement must be implemented. Governments must establish mentorship programs to facilitate the transfer of knowledge and experience from experienced RE professionals to local government employees. Innovative synergy with academic institutions can translate to RE policy formulation and implementation, catalyze job creation,

foster economic resilience, and empower citizens with the tools needed to thrive in a green economy. As towns and cities across the globe seek to become more sustainable, the practical implications of investing in local training programs cannot be overstated; they represent a visionary step toward a more sustainable and equitable future for all.

## 6 Limitations and future research

The major limitation of this study is its methodological approach. The exclusive use of a qualitative design, employing inductive reasoning through interview sessions only, limits the scope of data and perspectives. Enhancing the rigor and validity of future research on this topic may require employing a quantitative or mixed-method approach. This would allow for collecting both qualitative and quantitative data, providing a more comprehensive understanding of the phenomenon under investigation. Despite achieving data saturation, the study's small sample size represents a recognized limitation. Future research should prioritize a larger sample size to strengthen the findings and improve generalizability beyond the South African context.

## 7 Conclusion

Skill development is a critical driver of RE success at the local government level, enabling local communities to harness the potential of clean energy technologies effectively. Local governments are vital in fostering this development through supportive policies, educational partnerships, and community engagement. By prioritizing skill development and addressing the specific needs of local populations, local governments can create a skilled workforce capable of leading the transition to a sustainable energy future. As the world moves toward a greener economy, the collaboration between local governments, academic institutions, and communities will be instrumental in achieving RE goals, ultimately contributing to enhanced energy security, economic growth, and environmental sustainability.

In all, to bridge the RE skills gap and facilitate successful adoption and transition to RE at the grassroots level, the identified solutions, such as providing RE training and networking opportunities for staff, ensuring synergy with academic institutions and enhancing inclusive community engagement in RE participation must be prioritized.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by University of KwaZulu-Natal Human and Social Science Research Ethics Committee. The studies were conducted in accordance with the

local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

OO: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. ES: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. NN: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare that financial support was received for the research and/or publication of this article. The author(s) declare that this article is one of the outputs from the research project sponsored by the Local Government Sector Education and Training Authority (LGSETA).

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsuep.2025.1525160/full#supplementary-material>

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