

EVI-SICEE-SCOPING STUDY REPORT-01

Evidence for informing optimization and scaling of youth and women-led clean energy enterprises and business models in South Africa

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ACRONYMS

Acronym	Full name
AET	Amahlathi Eco-Tech
CEE	Clean Energy Enterprise
CIC	Climate Innovation Centre
CICSA	Climate Innovation Centre South Africa
CSIR	Council for Scientific and Industrial Research
DBSA	Development Bank of Southern Africa
DFI	Development Finance Institution
DMRE	Department of Mineral Resources and Energy
DSBD	Department of Small Business Development
DTIC / the dtic	Department of Trade, Industry and Competition
EPC	Engineering, Procurement and Construction
EVI-SICEE	Evidence for Informing the Scaling of Youth- and Women-Led Clean Energy Enterprises
EWSETA	Energy and Water Sector Education and Training Authority
GCIP	Global Cleantech Innovation Programme
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GHG	Greenhouse Gas
GYN	Green Youth Network
IDC	Industrial Development Corporation
IEA	International Energy Agency
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
JET	Just Energy Transition
JET-IP	Just Energy Transition Investment Plan
NDP	National Development Plan
NEF	National Empowerment Fund

NGO	Non-Governmental Organisation
NYDA	National Youth Development Agency
PAYG	Pay-As-You-Go
PEETS	Process, Energy and Environmental Technology Station
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
REEEP	Renewable Energy and Energy Efficiency Partnership
SABS	South African Bureau of Standards
SANEDI	South African National Energy Development Institute
SAREBI	South African Renewable Energy Business Incubator
SAWEA	South African Wind Energy Association
SEDA	Small Enterprise Development Agency
SEforALL	Sustainable Energy for All
SEZ	Special Economic Zone
SME	Small and Medium Enterprise
TIA	Technology Innovation Agency
TVC	Technology Venture Capital

TVET	Technical and Vocational Education and Training
UJ	University of Johannesburg
UJ PEETS	University of Johannesburg Process, Energy and Environmental Technology Station
UN	United Nations
UNDP	United Nations Development Programme
UN Women	United Nations Entity for Gender Equality and the Empowerment of Women
VC	Venture Capital
WEF	Women Empowerment Fund
YCF	Youth Challenge Fund
ZAR	South African Rand

KEY DEFINITIONS

Term	Definition
Clean Energy	Energy derived from renewable or low-emission sources that minimize environmental impact, including solar, biogas, and clean cooking technologies.
Clean Energy Enterprise (CEE)	A business that provides products or services related to clean energy generation, distribution, or use.
Renewable Energy	Energy sourced from naturally replenishing resources such as sunlight, wind, water, and biomass.
Solar Energy	Energy harnessed from sunlight using technologies such as photovoltaic (PV) panels and solar thermal systems.
Biogas	A renewable gas produced from the anaerobic digestion of organic waste, used for cooking, heating, or electricity generation.
Clean Cooking Technologies	Energy-efficient and low-emission cooking solutions such as improved cookstoves, biogas systems, and electric or solar cookers.
SMEs	Small, Medium Enterprises defined under South African legislation based on size, turnover, and employment thresholds.
Women-led Enterprise	A business that is owned, managed, or primarily controlled by women.
Youth-led Enterprise	A business owned or managed by individuals typically between the ages of 18 and 35.
Energy Access	The availability of reliable, affordable, and modern energy services for households and enterprises.
Just Energy Transition (JET)	A shift to a low-carbon energy system that ensures social equity, job creation, and inclusion of vulnerable groups.
Value Chain	The full range of activities involved in producing and delivering a product or service, from design to end use.
Business Model	The strategy through which an enterprise creates, delivers, and captures value.
Financing Model	The structure through which financial resources are mobilized for energy projects, including loans, grants, equity, and blended finance.
Blended Finance	The use of concessional or public funding to attract private investment by reducing risk.
Impact Investment	Investments made to generate positive social and environmental outcomes alongside financial returns.
Distributed Renewable Energy (DRE)	Decentralized energy systems that generate power close to the point of use, such as rooftop solar or small-scale biogas systems.

Solar Home System (SHS)	A small-scale solar PV system designed to provide electricity to individual households, typically in off-grid areas.
Pay-As-You-Go (PAYG)	A financing model where users pay for energy services in small, incremental payments rather than upfront costs.
Public-Private Partnership (PPP)	A collaborative arrangement between government and private sector entities to finance and implement projects.
Green Economy	An economic system that promotes environmental sustainability, resource efficiency, and low-carbon development.
Circular Economy	An economic model focused on minimizing waste and maximizing resource reuse and recycling.
Energy Efficiency	The use of less energy to perform the same task or provide the same service.
Gender-Responsive Approach	An approach that considers gender-specific needs and barriers to ensure equitable participation and benefits.
Inclusive Energy Transition	A transition to sustainable energy systems that actively includes marginalized groups such as women and youth.

Executive summary

South Africa's clean energy transition presents significant opportunities for women and young entrepreneurs to contribute to enterprise development, job creation, innovation and a more inclusive economy. Opportunities are emerging across solar energy, biogas and clean cooking, including technology development, equipment supply, installation and maintenance, energy services, community-based enterprises and waste-to-energy solutions. However, participation in these opportunities remains uneven and is influenced by access to finance, skills, markets, technology, networks and institutional support. This scoping study, undertaken under the EVI-SICEE project, examines the conditions shaping women- and youth-led clean energy enterprises (CEEs) in South Africa. It reviews clean energy technologies and value-chain opportunities, business and financing models, systemic barriers, relevant policies and the support ecosystem available to entrepreneurs. The study used a scoping review approach informed by Arksey & O'Malley (2005) and the PRISMA Extension for Scoping Reviews (Tricco et al., 2018). Literature published between 2010 and 2025 was reviewed, including academic studies, policy documents, institutional reports and relevant grey literature. The search initially identified 162 records, of which 49 were included in the final review following screening and assessment.

The review shows that women and young entrepreneurs can participate in clean energy through a range of business models, including direct product sales, installation and maintenance, technology commercialisation, energy-as-a-service, pay-as-you-go and lease-to-own arrangements, institutional contracting, and community or cooperative models. These models provide different entry points into solar, biogas and other clean energy value chains.

However, access to finance remains a major constraint. Clean energy enterprises require finance not only at start-up but also for technology development, testing and certification, equipment, working capital, demonstration and commercial expansion. Conventional financing requirements such as collateral, credit histories, financial records and demonstrated turnover can be particularly difficult for emerging women and young entrepreneurs. Recent evidence continues to identify financial constraints as a significant challenge for women entrepreneurs in South Africa (Machingambi & Rankhumise, 2026). Other important barriers include regulatory and certification requirements, limited technical and business skills, weak market development, supply-chain constraints and restricted access to established business networks.

Although many of these challenges also affect other SMEs, women and young entrepreneurs may have fewer accumulated financial resources, business track records and professional networks with which to navigate them. Women can also experience gender-related barriers within traditionally male-dominated technical and business environments. South Africa has several institutions and programmes that can support clean energy entrepreneurship, including business incubators, universities and research organisations, skills-development institutions, development-finance organisations and green-economy support platforms. These organisations can provide incubation, technical expertise, technology validation, skills, market intelligence and connections to finance and markets. However, most are not exclusively targeted at women- and youth-led CEEs. The key issue is therefore whether women and young entrepreneurs can effectively access and benefit from the support available. The case studies reviewed demonstrate that women- and youth-led enterprises are already developing and commercialising innovative solutions across the solar and biogas value chains, while creating employment, expanding energy access and responding to local environmental and socio-economic needs. However, the review found limited documented evidence on women- and youth-led clean cooking enterprises in South Africa, highlighting an important data and research gap that will be further explored through primary data collection under the EVI-SICEE project.

Another major gap identified by the study is the lack of reliable gender- and age-disaggregated data on clean energy enterprises in South Africa. Available datasets do not provide a comprehensive picture of how many CEEs are women- or youth-led, where they are located, the technologies in which they operate, or how many progress from start-up to commercial scale. Similar data gaps exist within enterprise-support programmes, making it difficult to determine how effectively existing interventions reach women and young entrepreneurs. The review also identifies limited South Africa-specific evidence on which business models are most viable for women- and youth-led CEEs, which financing mechanisms best support enterprise scaling, and which incubation and support interventions produce sustained commercial outcomes. Better monitoring and longitudinal research are therefore required.

The study shows that strengthening women- and youth-led CEEs requires more than supporting individual entrepreneurs. It requires a coordinated and inclusive clean energy innovation ecosystem that connects skills, technology development, incubation, certification, finance, markets and business networks. A clearer enterprise-scaling pathway is needed: from skills and innovation to technology development and validation to incubation to testing and certification to appropriate finance to market access and procurement to commercial scaling. Government, financial institutions, universities and research organisations, incubators, industry and development partners therefore need to strengthen coordination and ensure that women and young entrepreneurs can access these opportunities. Improved gender- and age-disaggregated data are also necessary to monitor participation and enterprise outcomes. Overall, an inclusive clean energy transition should be assessed not only by the growth of renewable energy, but also by who participates in the emerging economy and who benefits from it. Enabling women- and youth-led CEEs to build viable and scalable businesses can contribute simultaneously to clean energy development, employment creation, entrepreneurship and a more inclusive and just energy transition in South Africa.

1. Introduction

The transition to clean and sustainable energy presents both a pressing challenge and a transformative opportunity for inclusive development in Africa. In South Africa, where the energy landscape remains heavily dependent on fossil fuels, fostering women and youth-led clean energy enterprises (CEEs) offers a dual pathway to advancing climate resilience and socio-economic empowerment. Despite growing recognition of their potential, systemic barriers, ranging from limited access to finance and markets to gendered institutional and policy constraints continue to hinder women and youth from fully participating in and benefiting from the clean energy economy. This scoping study seeks to generate evidence to inform the optimization and scaling of women and youth-led clean energy enterprises and business models. Throughout this scoping study, “clean energy” is used as the primary umbrella term to encompass the energy technologies, products, services and enterprise activities examined in the study. Within this broad framing, particular attention is given to renewable and lower-emission energy solutions, including solar energy, biogas and clean cooking technologies.

The overall objective is to identify the enabling and constraining factors that shape access to investment opportunities within the CIE ecosystem and to highlight best practices and policy levers that can be replicated and scaled for greater impact across Africa. By grounding the analysis in both empirical data and policy review, the study aims to contribute actionable insights that support a just, inclusive, and sustainable energy transition.

The African Centre for Technology Studies (ACTS), with funding from the International Development Research Centre (IDRC), is implementing an initiative that supports youth- and women-led or -owned small and medium enterprises (SMEs) to generate evidence for scaling up transformative clean energy enterprises in Kenya, Malawi, Uganda and South Africa.

As part of this broader initiative, the University of Johannesburg (UJ) conducted a scoping study to explore the clean energy landscape in South Africa. This scoping paper contributes to the overarching project focusing on “generating evidence to inform piloting, optimizing, and scaling clean energy best practices to empower and transform women and youth.” In South Africa, SMEs whether formally registered or informal, are central to economic growth and employment creation. This desk-based study employs a literature review and mapping exercise to examine the clean energy sector, focusing on its technologies, value chains, and the systemic barriers and enablers affecting transformative youth- and women-led enterprises. The study adopts a gender-responsive analytical framework, with a specific focus on solar energy and biogas two sectors with high potential to generate entrepreneurial and employment opportunities for women and youth. These value chains present diverse entry points, including equipment manufacturing, servicing, installation, and distribution. The findings aim to guide the optimization and scaling of clean energy enterprises that respond to the unique needs and capacities of women and youth.

1.1 Background

South Africa’s energy system is shaped by its complex socio-political and economic history, with deep-rooted inequalities stemming from apartheid-era policies. During this period, energy access was highly unequal, as Black communities were deliberately excluded from reliable electricity services, reinforcing systemic marginalization. Following the end of apartheid, the democratic government made concerted efforts to redress historical imbalances through initiatives such as the National Electrification Programme (NEP) launched in the 1990s, which significantly expanded access to electricity in previously underserved areas. By 2010, these efforts had resulted in over 85% of South African households being connected to the national grid, marking a major milestone in energy access.

In South Africa, approximately 78% of electricity is produced from coal-fired power stations, many of which were constructed during the 1960s and 1970s under apartheid. The country is currently experiencing load shedding, largely due to ageing infrastructure and corruption in coal procurement and power plant contracts, which has contributed to Eskom accumulating about USD 24 billion in debt. Load shedding refers to the intentional interruption of electricity supply to reduce pressure on the national grid. Renewable energy contributes only about 6.7% to the total energy mix, which is significantly lower than coal-based generation. However, there has been gradual progress in renewable energy adoption over recent years. Compared to 2013, there has been noticeable growth in wind, solar photovoltaic (PV), and concentrated solar power (CSP), with their operational capacities steadily increasing up to 2021. (Mukumba & Chivanga, 2023)

The clean energy sector in South Africa plays a key role in addressing the country's growing energy demands while transitioning towards more sustainable and environmentally friendly energy solutions. The clean energy transition in South Africa presents a critical opportunity to advance inclusive economic growth while addressing the pressing challenges of energy poverty, unemployment, and environmental degradation. Within this evolving landscape, women and youth entrepreneurs are increasingly emerging as key actors in driving innovation, expanding energy access, and promoting local resilience. Their participation not only contributes to climate and energy objectives but also strengthens the social and economic dimensions of a just energy transition.

In South Africa, clean energy represents only 4% of the total energy mix, highlighting the country’s continued dependence on coal as its primary energy source. The second chart breaks down the composition of renewable energy supply. Here, bioenergy is the leading renewable source, providing 69% of renewable supply, followed by solar energy at 27%. Hydropower and marine energy make up 3%, while wind and geothermal energy contribute insignificantly (around 0%) (IRENA, 2022).

The solar and biogas sub-sectors, represent two critical pillars of South Africa's renewable energy landscape, each addressing unique challenges related to energy access, environmental sustainability, and equitable participation in the clean energy economy. Empowering youth and women-led clean energy enterprises (CEEs) is central to achieving a just and inclusive transition. Their participation not only fosters innovation and entrepreneurship but also ensures that the benefits of the clean energy transition are equitably distributed, contributing to sustainable development goals (SDGs) and broader socio-economic transformation across the region.

South Africa has made significant strides in advancing clean energy initiatives. However, several challenges hinder the complete optimization and scaling of youth- and women-led clean energy enterprises. Addressing these gaps requires evidence-driven interventions that effectively connect market opportunities with the needs, skills, and ambitions of women and youth. Implementing inclusive strategies such as targeted financial access, entrepreneurship training, mentorship, and gender-sensitive policy frameworks can be transformative in empowering these groups to participate meaningfully in the clean energy economy. Expanding access to diverse and flexible financing mechanisms, including microcredit, blended finance, and impact investment, will strengthen their capacity to scale clean energy enterprises in South Africa's clean energy sector.

This scoping study seeks to generate evidence-based insights on the factors that enhance or hinder women's and youth's participation in clean energy enterprises and investment ecosystems in South Africa. The study further aims to identify best practices and scalable business models that can promote gender equality, youth empowerment, and inclusive economic growth within the broader renewable energy transition across Africa. This study also seeks to examine the current landscape, challenges, and opportunities for youth-and women-led clean energy enterprises in South Africa, with a particular focus on the solar, biogas and clean cooking subsectors.

While the scoping study considers solar energy, biogas and clean cooking within the broader clean energy landscape, the depth of analysis across these subsectors reflects the availability of South Africa-specific enterprise evidence. Solar and biogas constitute the primary enterprise-focused subsectors of the review, as the available literature and case-study evidence enabled greater examination of women- and youth-led entrepreneurial activity, technologies and business models. Clean cooking was retained as an important complementary subsector because of its relevance to energy access, household energy use and inclusive clean energy transitions; however, the review identified very limited documented evidence on women- and youth-led clean cooking enterprises in South Africa. Clean cooking is therefore treated primarily as an emerging area for further investigation rather than as a subsector with an established enterprise evidence base.

The study aims to identify the systemic barriers that limit the participation and growth of these enterprises while highlighting pathways to strengthen their engagement across the clean energy value chain. By generating actionable insights and evidence-based recommendations, the study contributes to advancing gender equality, youth empowerment, and inclusive participation within South Africa's evolving energy transition. Ultimately, it supports the national and regional agenda of achieving equitable energy access, fostering innovation, and driving sustainable socio-economic development through clean energy.

1.2 Objectives of the scoping report

The overarching objective of this scoping report is to generate evidence that deepens the understanding of systemic factors influencing women's and youth's access to investment and business opportunities in clean energy enterprises. The study aims to inform strategies for optimizing and expanding youth-and women-led participation within the clean energy ecosystem through evidence-based insights, actor engagement, and policy recommendations.

Specifically, the scoping report seeks to address the following questions:

- 1.) What systemic barriers limit women's and youth's entry or growth in clean energy ecosystem in South Africa?
- 2.) What are the business models for women and youth-led CEE in South?
- 3.) What types of financial models exist to support youth and women-led CEEs in South Africa?
- 4.) What are the key opportunities that contribute to the success of women-led and youth-led CEEs in South Africa?
- 5.) What policies and institutional frameworks govern women and youth participation in clean energy enterprises in South Africa and what are the policy gaps?

2. Methodology

2.1 Conceptual framework

The conceptual framework for the South Africa scoping study under the EVI-SICEE project provides an integrated structure for understanding how women and youth engage with the country's clean energy ecosystem. It is designed to examine the dynamics, opportunities, and systemic challenges shaping women's and youth's participation in clean energy entrepreneurship, with a particular focus on the solar, biogas and clean energy sectors as shown in Fig.1 below. The review considered solar energy, biogas and clean cooking, with solar and biogas serving as the principal enterprise-focused subsectors and clean cooking included as an exploratory subsector to assess available evidence and identify potential opportunities and research gaps relating to women- and youth-led entrepreneurship.

The framework provides an approach to map out key actors, technologies, business models, and enabling conditions that support or constrain youth- and women-led clean energy enterprises. This approach provides a system-wide understanding of how clean energy entrepreneurship can contribute to inclusive development while identifying specific barriers that hinder participation, such as limited access to finance, technical skills, and policy support.

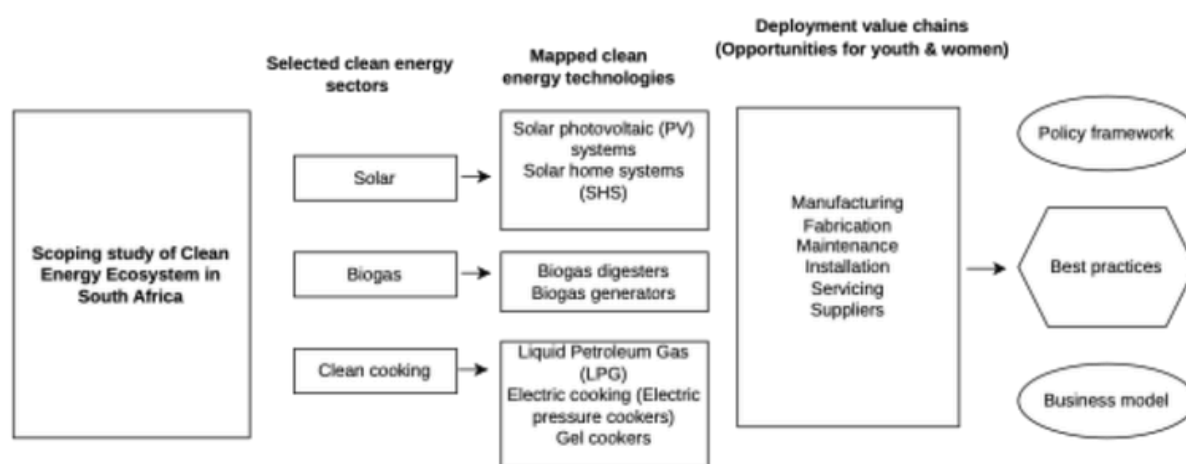


Figure 1: Conceptual framework for selection of clean energy enterprises in South Africa

The conceptual framework also integrates three cross-cutting dimensions that shape the enabling environment for inclusive clean energy entrepreneurship. The policy framework forms the foundational layer, influencing how gender, energy, and small enterprise development policies interact to support or limit participation. The second dimension, business models, explores innovative approaches such as community-based enterprises, pay-as-you-go systems, and cooperative ownership structures that enable sustainable participation in the renewable energy economy. The third dimension focuses on best practices, drawing from successful case studies. Overall, this framework provides a systems-based lens for analyzing South Africa's clean energy ecosystem. It connects the technical dimensions of clean energy production with the broader social and economic processes that enable empowerment. By examining the intersections between policy, market dynamics, and enterprise development, the framework helps to identify pathways for scaling best practices and optimizing inclusive business models. Ultimately, it positions solar and biogas technologies as strategic entry points for advancing gender equity, youth employment, and sustainable energy access key elements in achieving a just and inclusive energy transition in South Africa.

2.2. Methodological framework

To generate evidence that informs the optimization and scaling of youth-and women-led clean energy enterprises in South Africa, this study adopted a scoping review methodology. The approach is grounded in the frameworks developed by Arksey & O'Malley (2005), refined by (Levac et al., 2010), and later formalized by (Tricco et al., 2018) through the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). This methodology was chosen for its flexibility in exploring emerging evidence, identifying research gaps, and synthesizing a broad range of literature relevant to gender, youth, and clean energy innovation. Scoping reviews are particularly useful in mapping complex and multidisciplinary fields, such as South Africa's clean energy ecosystem by identifying available evidence, clarifying conceptual boundaries, and highlighting areas for further investigation (Munn et al., 2018).

In this study, the scoping review aimed to map the current landscape of clean energy entrepreneurship in South Africa, focusing specifically on solar and biogas sectors, and to document the challenges, and opportunities for women and youth within these value chains. The research was guided by a gender-responsive and youth-inclusive framework, emphasizing systemic factors such as access to finance, skills development, market participation, and policy support that influence the success or failure of inclusive CEEs.

The PRISMA-ScR framework was applied due to its comprehensive and systematic approach to sourcing and evaluating diverse types of literature, including journal articles, policy papers, project reports, conference proceedings, and organizational documents. The review drew from multiple databases such as Scopus, ScienceDirect, Sage, and Google Scholar as well as South African institutional and government sources, including the Department of Mineral Resources and Energy (DMRE), CSIR, SANEDI, and Stats SA, to ensure both academic and policy relevance.

PRISMA-ScR method facilitated a broad and integrative synthesis of evidence, encompassing qualitative and quantitative insights. The inclusion criteria focused on studies and reports published between 2010 and 2025, with emphasis on South African enterprises operating in the clean energy space and demonstrating women and youth participation (see Fig.2). Studies unrelated to clean energy, or those without a gender or youth focus, were excluded to ensure thematic alignment.

Data were systematically charted, categorized, and analyzed using a thematic approach. Each document was coded according to the type of enterprise (women-led, youth-led, or mixed), technology focus (solar or biogas), and type of intervention (policy, financing, capacity building, or market development).

The findings were then synthesized to provide an overview of the enabling and constraining factors shaping women and youth participation in South Africa's clean energy landscape.

The scoping study adopted a structured and iterative methodological process adapted from Arksey and O'Malley (2005) and Tricco et al. (2018). The approach was designed to systematically map existing literature, policies, and initiatives in the solar and biogas sectors, with a particular focus on youth- and women-led CEEs. Figure 2 below illustrates the steps followed in conducting the scoping review.

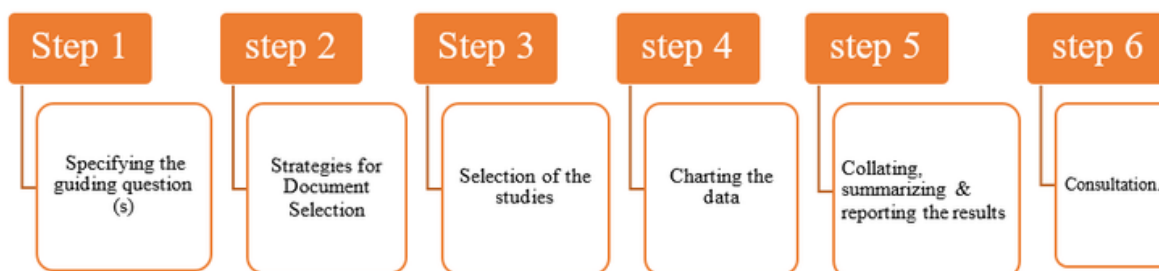


Figure 2: Steps in conducting scoping reviews (Arksey & O'Malley, 2005)

Step 1: Defining the Research Questions and Objectives

As with other systematic review processes, the first step involved defining clear and focused research questions to guide the study. A well-formulated research question establishes the scope, relevance, and boundaries of the review. The overarching question guiding this study was: What systemic factors prevent women and youth from accessing investment and entrepreneurship opportunities in South Africa's clean energy sector.

To operationalize this, several sub-questions were defined:

- What technological innovations, business models, and value chain activities involving women and youth exist in South Africa's solar and biogas sectors?
- What initiatives, programs, and projects support women's and youth's participation in clean energy enterprises?
- What are the key policies, regulations, and institutional frameworks shaping women's and youth's participation in solar and biogas enterprises?
- What financing mechanisms/models or business models are being used to promote youth-and women-led CEEs?
- What are the key barriers faced by women and youth entrepreneurs in South Africa's clean energy ecosystem?

Step 2: Document Selection Strategy

To ensure comprehensive coverage, a multi-source document retrieval strategy was applied to identify both published and grey literature. The inclusion criteria were carefully defined to capture evidence relevant to women and youth participation in clean energy entrepreneurship.

The following parameters guided document selection:

- Time frame: Only studies, reports, and policy documents published between 2010 and 2025 were included to capture recent developments in South Africa's energy transition.
- Geographical focus: The primary focus was South Africa, with comparative references to Sub-Saharan Africa where applicable.

- Sectoral focus: The study concentrated on solar energy, biogas, and clean cooking—key technologies with potential for youth and women entrepreneurship.
- Subject scope: The review included literature addressing innovation, business models, financing mechanisms, and gender participation in clean energy enterprises.
- Sources: Searches were conducted through academic databases (e.g., Scopus, ScienceDirect, Emerald), government portals (e.g., Department of Mineral Resources and Energy, SANEDI), development agencies (e.g., UNDP, USAID, GIZ, IRENA), and local institutions such as the CSIR and universities.

Studies were excluded if they lacked a focus on women and youth, or if they examined large-scale utility projects rather than small and medium enterprises (SMEs) in the clean energy sector.

Step 3: Selection strategies

To address the research questions guiding this scoping study, a two-stage document retrieval approach was adopted, adapted from the methodologies proposed by Tricco et al. (2018) and (Page et al., 2021). The purpose of this stage was to systematically identify and analyze literature, policy documents, and institutional reports that provide evidence on women's and youth's participation in South Africa's clean energy sector specifically within the solar and biogas value chains.

The first stage involved an extensive electronic search of peer-reviewed and grey literature to capture technological innovations, business models, financing mechanisms, and policy frameworks relevant to clean energy enterprises. Searches were conducted using academic databases such as ScienceDirect and Google Scholar and institutional websites. The second stage included a manual search of publications, reports, and strategy documents from governmental and non-governmental organizations, including the Department of Mineral Resources and Energy (DMRE), South African National Energy Development Institute (SANEDI), Council for Scientific and Industrial Research (CSIR), Industrial Development Corporation (IDC), Department of Trade, Industry and Competition (DTIC), UNDP, USAID, World Bank, IRENA, GIZ, and WWF South Africa.

To ensure relevance to the study's objectives, the search strategy incorporated a series of keywords and Boolean combinations, such as: "women and clean energy entrepreneurship," "youth-led clean energy enterprises," "solar energy value chains," "biogas SMEs," "inclusive energy transitions South Africa," "clean energy financing mechanisms," "women in renewable energy," "youth and innovation in energy," and "business incubation clean energy South Africa." The search covered publications from 2010 to 2025, aligning with the period of South Africa's energy policy reforms and increased focus on inclusive renewable energy development.

For this scoping study, clean energy enterprises (CEEs) were defined as small and medium-sized enterprises (SMEs) involved in producing, distributing, or servicing energy technologies that reduce environmental impact and promote sustainability. The focus was on enterprises operating in the solar energy (e.g., photovoltaic systems, solar home systems) and biogas (e.g., digesters, waste-to-energy systems) sectors.

Inclusion criteria emphasized:

- Studies and reports published between 2010 and 2025.
- Evidence-based analyses or case studies related to women and youth participation in clean energy innovation, entrepreneurship, or value chain activities.
- Research focusing on policy frameworks, financing mechanisms and capacity development programs that support inclusivity in the clean energy sector.
- Documentation of barriers, best practices, and enabling factors shaping the participation of women and youth in solar and biogas enterprises.

Studies were excluded if they focused exclusively on large-scale energy systems such as utility-scale solar farms, national grid infrastructure, or non-renewable energy initiatives, as these fall outside the SME-oriented focus of the EVI-SICEE project.

The initial database search yielded 162 documents, including journal articles, policy briefs, institutional reports, and program evaluations. After removing duplicates and applying inclusion criteria, 49 documents were selected for detailed analysis and coded in an Excel database according to thematic relevance. These themes included;

1. Technological innovation and value chain participation of women and youth.
2. Business and financing mechanisms in solar and biogas enterprises.
3. Policy and institutional frameworks influencing inclusive clean energy development.
4. Systemic barriers limiting women and youth participation.

The rigorous screening process ensured a comprehensive and contextually grounded evidence base, capturing South Africa's evolving clean energy landscape and its intersection with gender and youth inclusion. The results of this process provided the foundation for mapping opportunities, identifying gaps, and informing recommendations on how to optimize and scale inclusive CEEs in South Africa.

Step 4: Charting the data

Following data collection, all relevant documents including journal articles, policy reports, and institutional publications were systematically organized and catalogued using an excel sheet. Each entry in the catalog captured essential bibliographic and analytical details, such as the author(s), year of publication, thematic area, and the specific research question addressed.

This structured catalog served as a central tool for synthesizing insights across multiple sources and ensuring analytical consistency throughout the scoping process. To maintain rigor, each document was reviewed and cross-referenced with bibliographies from key studies and institutional reports to ensure comprehensive coverage and avoid duplication. The selected studies were then validated through triangulation, where key findings were compared with established literature and empirical evidence from recognized energy and gender research in South Africa. This validation process helped confirm the credibility and relevance of each source, while also identifying areas of convergence or divergence across datasets.

Documents were further classified and grouped thematically to facilitate deeper analysis. The thematic categories reflected the core dimensions of the study, including:

- Women-led and youth-led clean energy enterprises;
- Solar and biogas sector innovations;
- Business models and financing mechanisms;
- Policy and regulatory frameworks;
- Barriers affecting women-led and youth-led clean energy enterprises.

Through this process, overlaps were identified and resolved, while data gaps were noted for further exploration during actor consultations and case study validation. This systematic charting approach ensured that the evidence base was both comprehensive and analytically coherent, enabling the study to generate meaningful insights into how women and youth participate in, and can be further supported within, South Africa's clean energy ecosystem.

Step 5: Collating, summarizing, and reporting the results

After organizing and charting the collected data, the next stage involved systematically collating, synthesizing, and presenting the findings to generate a coherent overview of the current evidence base. Information drawn from the reviewed literature, policy documents, and institutional reports was analyzed and consolidated to highlight key trends, patterns, and knowledge gaps regarding women's and youth's participation in South Africa's clean energy ecosystem particularly in the solar and biogas value chains (see Fig.3).

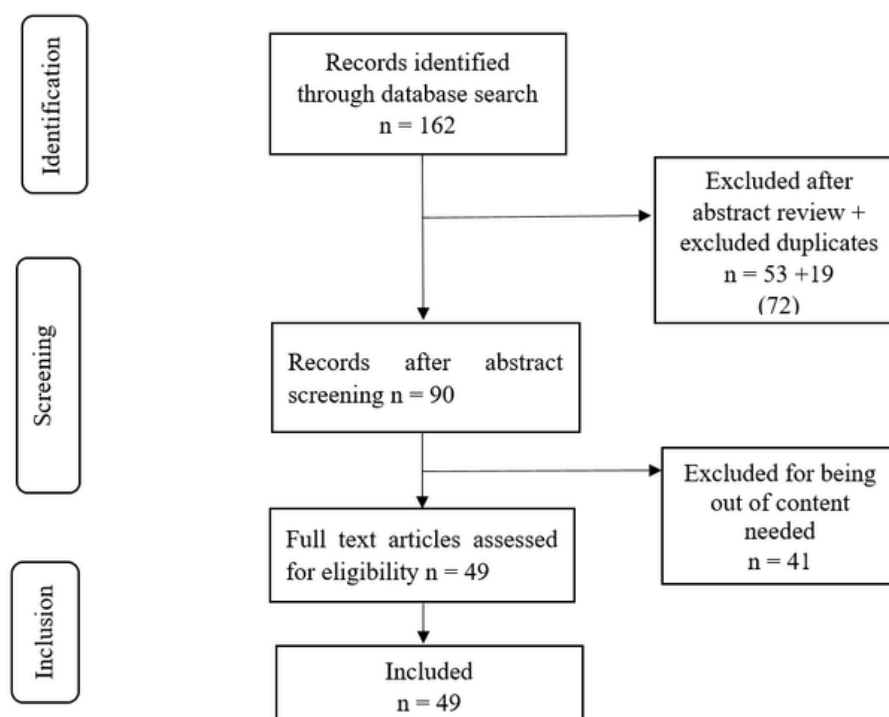


Figure 3: PRISMA flow chart

The synthesis process involved summarizing data under thematic categories that corresponded with the guiding research questions. These included:

- Technological innovations and business models featuring women and youth participation;
- Existing programs, initiatives, and policy frameworks supporting gender and youth inclusion;
- Financing mechanisms and business incubation models;
- Systemic challenges and enabling conditions for youth-and women-led CEEs; and
- Best practices and lessons learned from successful enterprises.

Findings were presented through tables, charts, and narrative summaries to illustrate the distribution, scope, and depth of the reviewed materials. This visual and thematic presentation enhanced the interpretability of the results and facilitated cross-comparison across different data sources and sectors. The final dataset, consisting of a carefully selected pool of studies and institutional reports, provided a solid foundation for understanding the structural and contextual dynamics influencing inclusive clean energy entrepreneurship in South Africa. Importantly, this process ensured representation of diverse perspectives from academic analyses and industry reports to grassroots innovations and government initiatives thereby offering a comprehensive and multi-dimensional view of the clean energy enterprise landscape.

Categories of documents analyzed

An analysis of the types of documents reviewed revealed a diverse evidence base, as shown in Fig.4. Peer-reviewed journal articles accounted for a significant proportion (65%), contributing empirical and conceptual insights on gender, youth, and clean energy entrepreneurship. A smaller share (22%) was reports which included; working papers, policy briefs, and technical manuals, reflecting ongoing research and operational experimentation within the field. Finally , websites had the smallest contribution to the scoping study, 12%.

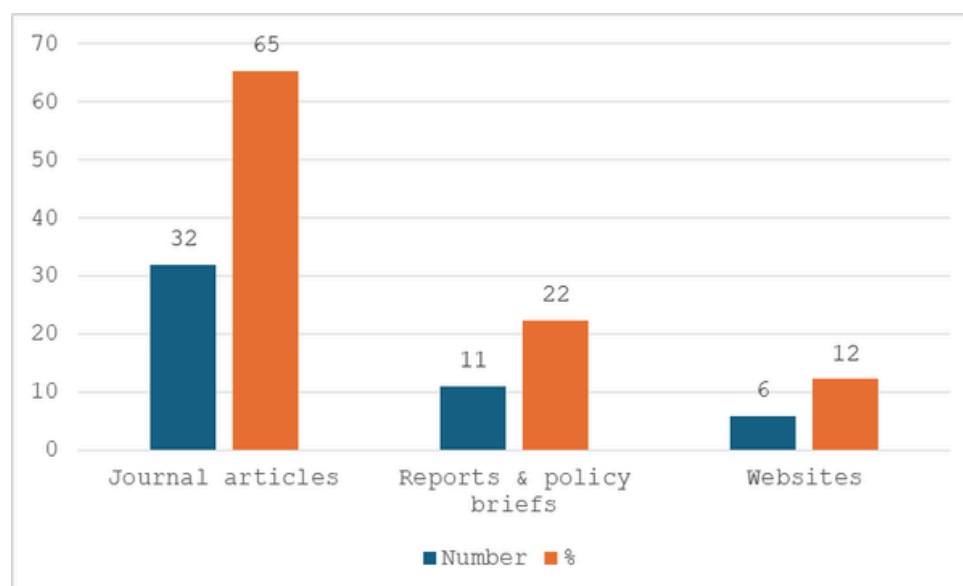


Figure 4: Categories of documents analyzed.

The evolving nature of this evidence base points to an expanding interest in inclusive clean energy entrepreneurship and the need for sustained research and documentation to guide future policy and practice.

Case Study Selection

The four enterprise case studies included in the scoping study; Amahlathi Eco-Tech Africa, Kusini Water, Kaeane Renewable Energy Developers, and His Grace Biogas Cooperative were identified through purposive case selection. The purpose was not to develop a statistically representative sample of South African clean energy enterprises, but to identify information-rich cases that illustrate different pathways through which women and youth participate in clean energy entrepreneurship. Enterprises were considered for inclusion based on the following criteria: (i) evidence of women or youth ownership, leadership, or substantial participation; (ii) active involvement in the clean energy sector, particularly within the solar or biogas or clean cooking value chains; and (iii) evidence of an identifiable clean energy technology, product, service, or business model. The four cases should therefore be understood as illustrative rather than representative of the broader population of women- and youth-led clean energy enterprises in South Africa. Their inclusion provides practical examples that complement the broader literature and ecosystem analysis and helps identify opportunities, constraints, and enterprise pathways requiring further investigation during subsequent empirical phases of the EVI-SICEE project.

3.Key findings

This section presents the key findings of the scoping study on women- and youth-led CEEs in South Africa. Drawing on the literature, policy and institutional documents, and enterprise case studies reviewed, the findings provide an overview of the country's evolving clean energy landscape and the conditions shaping the participation, development and scaling of women- and youth-led enterprises. The analysis focuses particularly on solar energy, biogas and clean cooking, while examining the broader ecosystem within which these enterprises operate. The section considers the implementation and geographic distribution of clean energy technologies, key actors in the sector, systemic barriers affecting women and young entrepreneurs, available financing mechanisms and business models, emerging enterprise and value-chain opportunities, relevant policy and regulatory frameworks, and clean energy hubs and support platforms. It also highlights important evidence and data gaps that limit understanding of women's and youth's participation in the sector and identifies areas requiring further investigation during subsequent phases of the EVI-SICEE project.

3.1 Renewable energy implementation in South Africa

South Africa's commitments under international agreements such as the Paris Agreement and COP26, along with recent national energy planning initiatives, have accelerated efforts to expand renewable energy adoption. These initiatives aim to diversify the country's energy mix by incorporating sources such as nuclear, biofuels, hydropower, solar, and wind energy (see Fig. 5). Expanding renewable energy not only reduces reliance on imported fossil fuels but also enhances energy security. With a growing population and ongoing infrastructure development, South Africa must strategically plan to meet its energy demands between 2020 and 2050. Despite these efforts, the overall implementation of renewable energy technologies remains relatively limited. However, ongoing policy and regulatory improvements are strengthening the sector. Progress has been made in areas such as Small-Scale Embedded Generation (SSEG), hydropower policies, carbon taxation, and improved energy efficiency measures (Smarte Anekwe et al., 2024).

This transformation presents SMEs with an important opportunity to reduce energy costs, improve energy security, and strengthen business resilience. Driven by policy reforms, technological advancements, and innovative mechanisms such as energy wheeling and modern power purchase agreements (PPAs), the evolving energy market is creating greater access to renewable energy solutions for businesses of all sizes. Increasingly, renewable energy is being recognised as more than a response to electricity shortages. For South African SMEs, integrating clean energy into business operations has become a strategic necessity for improving operational efficiency, enhancing competitiveness, mitigating energy-related risks, and reducing carbon emissions. As the country advances towards a low-carbon economy, adopting renewable energy is emerging as a key component of sustainable business growth (Melissa, 2026).

Currently, several renewable technologies are in use, including hydropower, geothermal, biomass, solar, wind, and biofuels. At the same time, emerging technologies such as marine energy, concentrated solar power (CSP), enhanced geothermal systems, cellulosic ethanol, and artificial photosynthesis are under development. Many of these technologies are approaching cost competitiveness with conventional energy sources and are gradually entering the market, although others still require further advancement before widespread adoption.

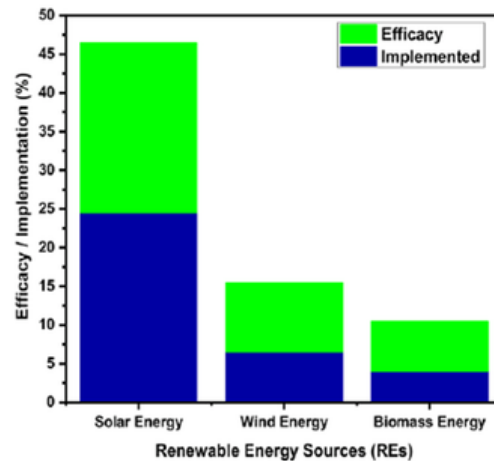


Figure 5. Evaluation of the Implementation and Effectiveness of some Renewable Energies in South Africa.
Source (Anekwe et al., 2024).

Despite progress, the effectiveness of renewable energy deployment is hindered by weaknesses in the policy framework. Research indicates that South Africa's approach to integrating renewable energy into its energy mix is often fragmented and lacks sufficient institutional and financial support. This limits the pace of renewable energy expansion and highlights the need for a more coordinated and robust policy environment to drive sustainable energy development.

The expansion of South Africa's clean energy sector is marked by impressive scale and promising potential, particularly in solar and biogas technologies, facilitated through policies like the Renewable Energy Independent Power Producer Procurement Programme. To contextualize this growth quantitatively and visually, the following figures provide a sense of the size and scale of these developments.

The national and utility-scale renewable energy statistics presented in this section are included primarily to provide macroeconomic and sectoral context for understanding the broader development of South Africa's clean energy market. While large-scale renewable energy programmes and installed-capacity trends influence the policy, investment and market environment in which smaller enterprises operate, utility-scale projects are not the primary unit of analysis in this scoping study. The review focuses principally on SME-level clean energy enterprises, particularly women- and youth-led CEEs, and their participation in clean energy value chains, business models, financing mechanisms, support ecosystems, and opportunities for enterprise development and scaling.

Installed renewable energy capacity in South Africa

South Africa's renewable energy capacity exceeds 3900 MW, encompassing wind, solar photovoltaic (PV), concentrating solar power (CSP), and biogas technologies. This reflects significant progress driven by surging energy demand and intermittent supply issues such as load-shedding, which have highlighted the need for reliable clean energy alternatives (Duvenhage et al., 2020).

Solar energy potential and installed capacity

Solar Irradiation and Theoretical Potential: South Africa receives one of the highest levels of solar irradiation globally, enabling a massive theoretical electricity generation potential exceeding 11,000 TWh, over 104 billion m² of suitable land area for CSP installations alone (Duvenhage et al., 2020). Since its inception in 2011, REIPPPP has facilitated a rapid increase in utility-scale and distributed solar PV installations. This policy innovation underpins local ownership and socio-economic benefits by fostering participation especially among women and youth in the renewable value chain (Müller & Claar, 2021).

Small and medium enterprises form a critical component in the manufacturing, installation, and maintenance stages of solar energy systems, driving innovation and creating localized energy solutions that empower communities (Akinboade et al., 2023).

Since 2010, solar photovoltaic (PV) generation has expanded dramatically, increasing from 32 TWh to 697 TWh, and projections indicate it could reach over 2,700 TWh by 2030. In South Africa, rooftop solar PV systems have experienced significant growth, particularly within the residential market. However, despite these advances, residential adoption remains relatively low, especially in rural and low-income communities, where affordability, awareness, and infrastructure challenges persist. To stimulate uptake, the government, through the Integrated National Electrification Programme (INEP), has introduced various incentives, including grants, tax exemptions, rebates, and feed-in tariffs. Yet, these measures have achieved limited success in driving large-scale adoption. A key factor influencing the effectiveness of such initiatives lies in household decision-making and behavioural dynamics. The acceptance or rejection of solar PV technology by end-users ultimately determines the pace and extent of adoption, underscoring the importance of aligning policy interventions with community needs, perceptions, and socio-economic realities (Chidembo et al., 2024). SMEs are playing an increasingly vital role in driving South Africa's solar PV sector, contributing to both energy access and economic inclusion. With the country facing persistent electricity shortages and frequent load-shedding, the demand for decentralized renewable energy solutions has surged, creating significant opportunities for SMEs across the solar value chain from manufacturing and installation to maintenance, financing, and distribution (DMRE, 2023). The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has been instrumental in stimulating private-sector participation, leading to the creation of over 90,000 jobs and supporting more than 100 small enterprises, including youth-and women-led ventures (Green Cape, 2024). Many SMEs in the solar PV sector operate within rooftop solar systems, commercial and industrial installations, and off-grid or hybrid solar solutions for rural communities.

Green Cape (2025) highlights that SMEs are central to the rapid expansion of distributed generation, benefiting from policy shifts such as lifting the 100 MW licensing cap (2021) and new net billing frameworks that allow independent producers to sell excess electricity back to the grid. These policy reforms have opened opportunities for local entrepreneurs to enter the sector, supported by financial instruments such as the Sustainable Energy Fund for Africa (SEFA), Industrial Development Corporation (IDC) Green Energy Fund, and Energy Performance Certificate (EPC) grants. Despite these opportunities, SMEs face persistent barriers, including high upfront capital costs, limited access to credit, and complex regulatory procedures that restrict scalability. Additionally, gender and youth inclusion remain limited due to technical skill gaps and lack of targeted financing.

Many households perceive SHSs as a long-term cost-saving investment, offering protection against rising electricity tariffs and reducing monthly energy expenses. Furthermore, access to solar energy is often associated with enhanced educational, economic, and healthcare opportunities in rural areas lacking grid connectivity, as reliable electricity supports study environments, small business activities, and essential medical services (Chidembo et al., 2024).

SMEs are central to the growth of South Africa's Solar Home Systems (SHS) market, which has become one of the most dynamic segments within the country's off-grid clean energy landscape. The demand for SHS has accelerated in response to persistent load shedding, rising electricity prices, and growing energy access gaps in both rural and peri-urban areas (Green Cape, 2024). These systems ranging from small pico-solar kits to multi-light systems with battery storage provide a decentralized, reliable, and sustainable energy alternative for households and microenterprises excluded from the formal electricity grid.

The SHS market presents a significant opportunity for inclusive economic growth, particularly for women and youth entrepreneurs. By engaging in installation, sales, and maintenance services, these enterprises contribute to local job creation and skills development while expanding clean energy access. Strengthening technical training, improving credit access, and promoting regulatory harmonization could further enhance SME competitiveness and sustainability in the SHS sector.

Biogas sector potential

The country's current biogas production has a technical potential of approximately 3 million normal cubic meters per day (Nm³/day). Commonly used feedstocks include livestock manure, food waste, wastewater, and sugarcane bagasse. The installed biogas energy capacity is estimated between 50 and 70 megawatts (MW), with potential for further growth through the expansion and diversification of feedstock sources. Nonetheless, the widespread adoption and scaling of municipal-scale biogas technologies have been constrained by a range of challenges technical, economic, cultural, social, and market-related (Kamusoko & Mukumba, 2025a). Maize stover (MS), an abundant agricultural residue in South Africa, offers an energy potential of approximately 94 PJ annually, equating to a considerable biogas resource from waste valorization (Kamusoko & Mukumba, 2025b). Despite being underdeveloped, the biogas sector permits waste-to-energy conversion that can improve rural energy access and contribute to sustainable agricultural waste management. Multi-actor collaboration is essential to unlock this sector's socio-economic benefits.

3.2 Overview of clean energy technologies in provinces in South Africa

Clean energy technologies, namely solar photovoltaic (PV), wind, and biomass are distributed across all provinces in South Africa, as illustrated in Figure 6 below.

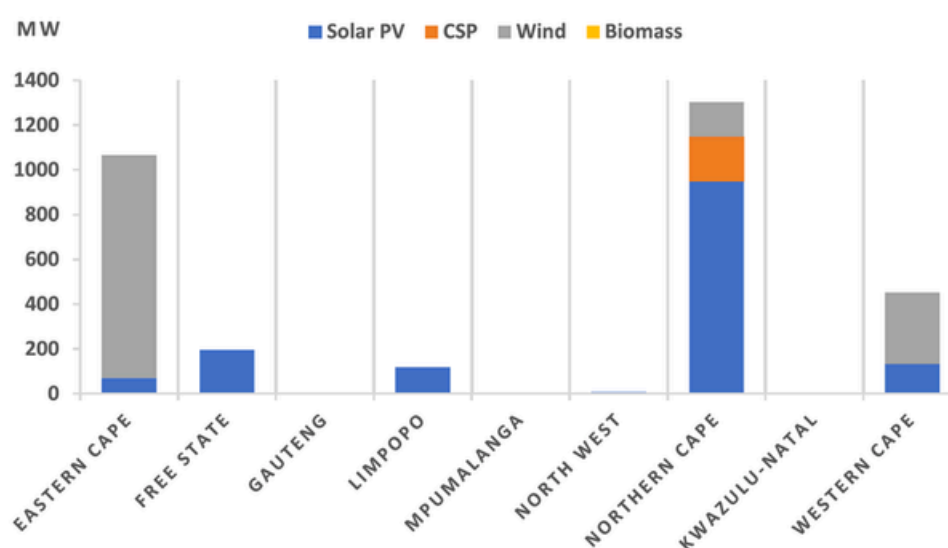


Figure 6: Electricity generation in South Africa (TWh) by technology type. Source (Müller & Claar, 2021).

The Northern Cape leads in renewable energy generation, followed by the Eastern Cape and Western Cape. The Eastern Cape, in particular, has strong wind energy potential, second only to the Western Cape, largely due to their coastal locations which enhance wind availability. The Eastern Cape ranks second after the Western Cape in biomass energy installations (Mukumba & Chivanga, 2023).

3.2.1 Solar technologies in South Africa

Solar energy is widely regarded as one of South Africa's most promising renewable energy sources, largely due to its favorable geographic location. The country experiences abundant sunshine, with most regions receiving over 2,500 hours annually and average daily solar radiation levels ranging between 4.5 and 6.5 kWh/m².

Across southern Africa, solar radiation is consistently available throughout the year. South Africa's average solar radiation is approximately 220 W/m² over a 24-hour period, which is significantly higher than the global averages observed in regions such as the United States (around 150 W/m²) and Europe or the United Kingdom (around 100 W/m²). As a result, the country possesses some of the most substantial solar resources globally, making solar energy one of the most accessible renewable options. The sector has expanded steadily, with increasing applications across various fields. Photovoltaic (PV) manufacturing capacity stands at approximately 5 MW annually, and local industries are actively producing solar water heating systems. Solar energy is utilized in a wide range of applications, including household devices, water heating, lighting, pumping systems, communications, transportation, and electricity generation. Like other renewable energy sources, solar power is environmentally friendly and safe, producing no emissions during operation since it relies on sunlight rather than fossil fuels. In 2022, solar energy contributed about 2.2% (approximately 5.2 TWh) to total energy demand, reflecting levels similar to 2021 but still below pre-2019 figures. The expansion of renewable energy has contributed to reduced production costs, job creation, increased foreign investment, and stronger regional collaboration. Nevertheless, challenges remain in fully integrating this sector into the national energy system. (Smarte Anekwe et al., 2024).

Solar PV technology, which uses solar panels comprising multiple photovoltaic cells typically made of silicon, is one of the most widely adopted and rapidly expanding renewable energy solutions globally, including in South Africa. In recent years, South Africa has seen notable solar PV deployment growth, driven by declining costs, increased government support, and growing awareness of renewable energy benefits. The country's abundant solar resources, particularly in regions like the Northern Cape with high solar irradiation levels, further bolster its potential for solar energy development. The government has introduced various initiatives and incentives, including the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), to encourage solar PV projects. Solar PV systems in South Africa offer several advantages, such as reducing electricity consumption, decreasing dependence on the national grid, and enabling users to sell excess electricity back to the grid through mechanisms like net metering or feed-in tariffs. Despite these benefits, challenges remain, including the intermittent nature of sunlight, installation space requirements, and high initial investment costs. However, technological advancements and supportive policy frameworks continue to drive the adoption and expansion of solar PV, contributing to South Africa's transition toward a cleaner and more sustainable energy future. According to data from South Africa's Department of Energy (DoE), the total installed capacity of solar PV increased from 1,350.6 MW in 2016 to 1,961.4 MW in 2021 (see Table 1), highlighting significant progress in the sector (Adebiyi & Moloi, 2024).

Table 1: Solar PV output in South Africa 2016-2021. Source (Adebiyi & Moloi, 2024).

Year	Generated Power (MW)
2013	262
2014	1164
2015	1353
2016	2176
2017	3451
2018	4805
2019	4908
2020	5994
2021	6316
2022	6326
2023	6164

In recent years, South Africa has made significant progress in expanding its renewable energy sector by installing large-scale solar power plants. In the Northern Cape province alone, over 100 independent power producers contribute a combined capacity of 900 MW, with more than 20 projects already connected to the grid. By the end of the first quarter of 2023, the country had installed 6,164 MW of solar PV capacity, a figure expected to exceed 12 GW within the next decade (Moyo, 2023). Of the current installed capacity, 2,200 MW originated from government initiatives, primarily through the Renewable Energy Independent Power Producer Program (REIPPP), while 3,964 MW came from private installations. The residential sector accounts for 11% of this capacity, with 30% comprising small-scale embedded generation systems under 1 MVA for residential, commercial, and industrial uses. Large-scale systems above 50 MW represent 27% of the capacity, and systems between 1 MW and 50 MW contribute 32%. Gauteng's City of Johannesburg leads in total installations with 586 MW, followed closely by Pixley ka Seme district municipality in the Northern Cape with 583 MW, accounting for over 20% of South Africa's solar PV capacity. Regarding residential installations, the City of Tshwane ranks highest with 22,956 systems, while the City of Cape Town follows with 21,342. eThekweni in KwaZulu-Natal boasts the largest average residential system size at 10.8 kWp, followed by Cape Town at 7 kWp.

The country has also witnessed a substantial increase in rooftop solar PV installations, growing from 983 MW in March 2022 to 4,412 MW by June 2023 a remarkable 349% increase within just over a year (Ferris, 2023a). The affordability of solar PV has made it more accessible to a broader range of consumers, particularly in provinces like Western Cape, Gauteng, and KwaZulu-Natal. This rapid adoption of rooftop solar has the potential to enhance energy resilience, reduce reliance on conventional grid systems, and support national climate change goals by decreasing fossil fuel dependence (Ferris, 2023b). Nevertheless, challenges remain in maximizing solar energy's potential. According to Adebisi & Moloi (2024), key obstacles include: (a) Grid Integration and Stability: The intermittent and variable nature of solar energy, influenced by weather and time of day, complicates grid stability and reliability. South Africa's current grid infrastructure is not fully equipped to manage large-scale solar integration, and upgrades are costly and technically complex. Although solar PV technologies have become increasingly cost-competitive, effective energy storage solutions remain a significant challenge. Battery energy storage systems (BESS), which are essential for storing excess electricity generated during periods of high solar irradiation for use during low-generation periods, continue to require substantial upfront investment despite declining global battery costs (Ngoy et al., 2025), (b) Geographical and climatic factors: While South Africa benefits from abundant sunlight, solar irradiation varies significantly across regions. Optimal locations for solar plants are often remote from urban centres, requiring efficient transmission systems. Dust accumulation on solar panels in arid areas reduces efficiency, necessitating regular cleaning and maintenance. Additionally, high temperatures can lower the performance of photovoltaic (PV) panels in extremely hot climates. Addressing these challenges will require collaborative efforts from the government, private sector, and research institutions to develop a sustainable and efficient solar energy infrastructure in South Africa (Adebisi & Moloi, 2024).

Solar PV installations across Provinces

Research on solar energy in South Africa consistently shows that deployment is uneven across provinces, with the Northern Cape emerging as the dominant solar hub, followed by the Eastern Cape and Western Cape (Akinbami et al., 2021b). This pattern reflects a combination of high solar irradiation, available land, and the location of large-scale private and utility projects. (Pulitzer Center, 2024) indicates that the Northern Cape ranks highest overall for renewable energy development, including solar PV and CSP, relative to other provinces. At the provincial and municipal level, the City of Johannesburg in Gauteng has the highest installed capacity at 586 MW, followed closely by Pixley ka Seme District Municipality in the Northern Cape with 583 MW. Together, these two areas represent more than 20% of South Africa's total installed solar PV capacity.

In terms of residential installations, the City of Tshwane leads with 22,956 systems, followed by the City of Cape Town with 21,342. eThekweni in KwaZulu-Natal has the largest average residential system size at 10.8 kWp, while the City of Cape Town follows at 7 kWp. The rapid growth of rooftop solar PV across South African provinces, especially in the Western Cape, Gauteng, and KwaZulu-Natal, is an important development. This expansion has been driven largely by the falling cost of solar technology, which has made it more affordable for a wider range of users. Eskom has also tracked and reported the increase in rooftop solar PV capacity, showing greater recognition of the role of renewable energy in South Africa's energy mix. (Adebiyi & Moloi, 2024).

The Northern Cape is repeatedly identified as having some of the best solar irradiation resources in the world, making it the preferred location for utility-scale solar farms. Evidence from provincial resource assessments and solar production studies also places the Northern Cape at the top in monthly energy yield, reinforcing its strategic importance for national solar expansion. The Eastern Cape and Western Cape are generally presented as secondary but still significant solar provinces. Pulitzer Center (2024) notes that both provinces host substantial renewable energy activity, although not at the same level as the Northern Cape. Their role is often tied to mixed renewable portfolios, where solar development coexists with strong wind energy potential, especially along the coast. Provincial solar development in South Africa is shaped not only by irradiance, but also by grid access, land availability, and the broader renewable energy mix (Akinbami et al., 2021b).

Another recurring argument is that solar growth in South Africa is constrained by transmission and grid capacity, especially in high-resource provinces. Even though the Northern Cape has the strongest solar potential, studies warn that the national grid was historically designed around coal generation in Mpumalanga, creating bottlenecks for evacuating electricity from new solar projects in the north-western part of the country. There is need for investment in transmission infrastructure if the province-level solar potential is to be fully realized (Kavitha, 2025). More recent project developments, such as large new solar plants in the Northern and Western Cape, suggest that private investment continues to expand despite these constraints (Solar Africa, 2024).

Overall, the literature presents South African solar development as highly spatially concentrated, with provincial disparities shaped by natural resource endowment, infrastructure, and policy-driven procurement mechanisms (Akinbami et al., 2021b). The evidence implies that future solar expansion will likely remain centered in the Northern Cape, while the Eastern Cape and Western Cape continue to play important supporting roles (Pulitzer Center, 2024).

Technology innovations with women and youth participation in the solar sector in South Africa

This section provides an overview of SMEs two key solar technologies; a) Photovoltaics, b) solar home systems, highlighting their development, adoption, and potential within the country. Since 2010, solar photovoltaic (PV) generation has expanded dramatically, increasing from 32 TWh to 697 TWh, and projections indicate it could reach over 2,700 TWh by 2030. In South Africa, rooftop solar PV systems have experienced significant growth, particularly within the residential market. However, despite these advances, residential adoption remains relatively low, especially in rural and low-income communities, where affordability, awareness, and infrastructure challenges persist. To stimulate uptake, the government, through the Integrated National Electrification Programme (INEP), has introduced various incentives, including grants, tax exemptions, rebates, and feed-in tariffs. Yet, these measures have achieved limited success in driving large-scale adoption. A key factor influencing the effectiveness of such initiatives lies in household decision-making and behavioural dynamics.

The acceptance or rejection of solar PV technology by end-users ultimately determines the pace and extent of adoption, underscoring the importance of aligning policy interventions with community needs, perceptions, and socio-economic realities (Chidembo et al., 2024).

SMEs are playing an increasingly vital role in driving South Africa's solar PV sector, contributing to both energy access and economic inclusion. With the country facing persistent electricity shortages and frequent load-shedding, the demand for decentralized renewable energy solutions has surged, creating significant opportunities for SMEs across the solar value chain from manufacturing and installation to maintenance, financing, and distribution (DMRE, 2023). The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has been instrumental in stimulating private-sector participation, leading to the creation of over 90,000 jobs and supporting more than 100 small enterprises, including youth- and women-led ventures (Green Cape, 2024). Many SMEs in the solar PV sector operate within rooftop solar systems, commercial and industrial installations, and off-grid or hybrid solar solutions for rural communities.

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Many households perceive SHSs as a long-term cost-saving investment, offering protection against rising electricity tariffs and reducing monthly energy expenses. Furthermore, access to solar energy is often associated with enhanced educational, economic, and healthcare opportunities in rural areas lacking grid connectivity, as reliable electricity supports study environments, small business activities, and essential medical services (Yesuf & Fields, 2026).

SMEs are central to the growth of South Africa's Solar Home Systems (SHS) market, which has become one of the most dynamic segments within the country's off-grid clean energy landscape. The demand for SHS has accelerated in response to persistent load shedding, rising electricity prices, and growing energy access gaps in both rural and peri-urban areas (Green Cape, 2024). These systems ranging from small pico-solar kits to multi-light systems with battery storage provide a decentralized, reliable, and sustainable energy alternative for households and microenterprises excluded from the formal electricity grid.

The SHS market presents a significant opportunity for inclusive economic growth, particularly for women and youth entrepreneurs. By engaging in installation, sales, and maintenance services, these enterprises contribute to local job creation and skills development while expanding clean energy access. Strengthening technical training, improving credit access, and promoting regulatory harmonization could further enhance SME competitiveness and sustainability in the SHS sector.

Existing women and youth led entrepreneurial initiatives in clean energy sector in South Africa

A major challenge in assessing women- and youth-led entrepreneurship in South Africa's clean energy ecosystem is the limited availability of comprehensive and disaggregated enterprise data. There is currently no consolidated national dataset that provides a reliable count of clean energy enterprises disaggregated simultaneously by gender, age, province, technology and enterprise size.

Available datasets tend to cover the broader SME population, general entrepreneurship, or particular components of the energy sector. Consequently, it is difficult to establish with precision how many women- and youth-led enterprises operate within South Africa's clean energy ecosystem, where they are located, the technologies in which they operate, and how many progress from start-up to commercial scale. This data limitation is itself significant because inadequate gender- and age-disaggregated information makes it difficult to assess whether opportunities associated with South Africa's energy transition are being distributed inclusively.

Although Gauteng is South Africa's smallest province in terms of land area, it is the country's main economic centre and has the highest concentration of business activity. In 2018, Gauteng accounted for approximately 34% of South Africa's gross domestic product (GDP), highlighting its central role in the national economy (Stats SA, 2018). Of the estimated 2.55 million SMEs operating across South Africa, approximately 903,220 (35.4%) were located in Gauteng, the largest share among the nine provinces. KwaZulu-Natal had the second-highest proportion at 15.3%, while the Northern Cape recorded the lowest concentration, with approximately 25,577 SMEs (1%) (Magodi et al., 2023). The concentration of enterprises in Gauteng reflects the province's relatively well-developed business environment, infrastructure and proximity to markets, financial services and skilled labour. These conditions have contributed to Gauteng's importance as a centre for entrepreneurship and enterprise development in South Africa (see Table 2).

Table 2: Distribution of SMEs across South Africa's provinces. Source: (Magodi et al., 2023)

Province	Number of SMEs	Distribution (%)
Gauteng	903,220	35.4
KwaZulu Natal	390,115	15.3
Limpopo	295,978	11.6
Western Cape	288,194	11.3
Mpumalanga	219,083	8.6
Eastern Cape	179,908	7.1
Northwest	126,725	5.0
Free State	121,740	4.8
Northern Cape	25,577	1.0
Total	2,550,540	100

Although reliable data on the provincial distribution of CEEs remain limited, the broader SME landscape indicates considerable potential for CEEs, innovation and inclusive economic development. The expansion of renewable energy markets creates opportunities for new and existing enterprises; however, their ability to participate and scale depends on the wider innovation ecosystem. Important conditions include access to appropriate finance, supportive institutions and intermediary organisations, knowledge and skills networks, partnerships, and viable market opportunities. For women- and youth-led CEEs in particular, the availability of these ecosystem resources is important, but so too is whether entrepreneurs can effectively access and benefit from them.

The limited availability of systematic data on women- and youth-led CEEs therefore represents both a research gap and a policy challenge. A more comprehensive national evidence base should track CEEs by gender and age of ownership/leadership, province, technology, enterprise size, formality and stage of development. Such information would make it possible to assess not only how many women and young people enter the clean energy economy, but also whether their enterprises survive, commercialise and scale. Without this evidence, it remains difficult to determine the extent to which South Africa's expanding clean energy economy is translating into genuinely inclusive entrepreneurial opportunities.

Despite the limited availability of disaggregated data, the study identified four women- and youth-led CEEs as case studies (in both the solar and biogas sectors) to provide context-specific insights into their entrepreneurial experiences and examine the barriers, enabling conditions and wider innovation ecosystem factors influencing their development and scaling in South Africa. More information on these case studies can be accessed in Appendix 5.

Existing women and youth led Entrepreneurial initiatives in solar sub sector in South Africa

South Africa's expanding solar energy subsector provides growing opportunities for small enterprises to participate in the country's transition towards cleaner and more decentralised energy systems. Entrepreneurial opportunities extend across the solar value chain, including solar PV installation and maintenance, energy-efficiency solutions, solar water heating, battery storage, distribution and solar-powered applications. These activities create opportunities for women and young entrepreneurs to contribute to technological innovation, employment creation and improved access to clean energy services. However, evidence on the participation of women- and youth-led enterprises in the solar subsector remains fragmented. Despite these data limitations, the EVI-SICEE study identified women- and youth-led enterprises operating within the solar and biogas sub-sectors, demonstrating their emerging contribution to South Africa's clean energy transition.

The four enterprise case studies examined under the EVI-SICEE project provide practical illustrations of how women and young entrepreneurs are participating in South Africa's clean energy ecosystem. Amahlathi Eco-Tech Africa, a women-led enterprise, demonstrates technology development and commercialisation through energy-efficiency and sustainable water-heating innovations, including the HotSpot retrofit device and Heat Radar technology. Kusini Water, a youth-led social enterprise, combines solar energy with water purification technologies and a community-based delivery model in which local "water champions" operate water kiosks. Kaeane Renewable Energy Developers illustrates entrepreneurial opportunities in decentralised biogas and waste-to-energy systems through the design and installation of biodigesters that convert organic waste into energy and fertiliser. His Grace Biogas Cooperative demonstrates a community and cooperative approach in which organic and agricultural waste is converted into biogas while generating potential livelihood, agricultural and environmental benefits. Together, the cases demonstrate that participation by women and youth extends beyond conventional energy generation to include technology development, installation and servicing, water-energy solutions, waste valorisation, community-based delivery and cooperative enterprise models. The cases are illustrative rather than representative of all women- and youth-led CEEs in South Africa; detailed case study reports are provided in Appendix 5.

Amahlathi Eco-Tech (AET)

Founded in 2012 by Sandiswa Qayi, Amahlathi Eco-Tech (AET) Africa is a pioneering women-led clean technology enterprise based in the Eastern Cape that focuses on energy efficiency and sustainable water heating solutions. The company's innovations bridge the gap between clean energy access and affordability, particularly for low- and middle-income households. AET's flagship product, the HotSpot, is a retrofit sleeve (see Fig. 7) for solar and electric geysers that enables users to heat only the required amount of water (e.g., 50 litres instead of a full 150 litres). This technology significantly reduces electricity consumption, making it especially beneficial in energy-constrained communities. The firm has also developed the Heat Radar, a system that recovers waste heat from cooling systems and repurposes it for water heating an innovation that complements solar-powered water heating and reduces carbon emissions.



Figure 7: Sandiswa Qayi, co-founder, AET-Africa, holding the Hotspot device. Source (Vukuzenzele, 2017)

Beyond technological innovation, AET Africa exemplifies how women-led enterprises contribute to job creation and skills development. The company has employed over 60 people at some point, many of them young technicians and engineers, in manufacturing, assembly, and installation processes. Despite facing challenges such as SABS certification delays, production costs, and limited market access, AET's experience highlights the potential of women entrepreneurs to drive localized clean technology innovation and influence gender inclusion in the energy economy (Mubika, 2025)

Kusini Water (Pty) Ltd

Kusini Water (Pty) Ltd, founded in 2016 by Murendeni Mafumo, is a youth-led social enterprise that leverages solar-powered filtration technology to provide clean and affordable drinking water to underserved communities in South Africa. Headquartered in Sandton, Johannesburg, the company has become one of the country's most recognized examples of youth innovation at the intersection of solar energy, water security, and social impact. The enterprise's technology utilizes solar PV systems to power mobile water purification units, as shown in Fig. 8 below.



Figure 8: Kusini water filtration system combining solar, reverse osmosis and ultrafiltration technologies.

These systems are designed for deployment in rural and peri-urban communities, schools, and healthcare facilities that lack reliable access to safe water. By integrating solar technology with a sustainable business model, Kusini Water addresses two critical development challenges clean energy and water access while creating employment and entrepreneurship opportunities for local youth.

Kusini Water's impact extends beyond technological innovation to community empowerment. The company partners with municipalities, NGOs, and corporate social investment (CSI) programs to install and maintain systems in marginalized communities. Its mobile "Water-on-Wheels" initiative distributes purified water to households using solar-powered purification stations. Through these initiatives, over 50 young people have been engaged in operations, maintenance, and outreach, while local women's groups participate in awareness and distribution programs (DMRE, 2023)

3.2.2 Biogas sector in South Africa

South Africa's biogas subsector remains relatively small compared to more established clean-energy technologies such as solar PV and wind. Nevertheless, the country has considerable potential for biogas development because of the large volumes of organic waste generated by households, agriculture, livestock production, wastewater treatment and food-processing industries. South Africa generated approximately 108 million tonnes of waste in 2017, of which approximately 55.2 million tonnes was general waste and 52.1 million tonnes hazardous waste. Only about 34.5% of general waste was recycled or recovered, with much of the remainder disposed of in landfill sites (Flanders, 2017; Smith, 2026). This substantial waste stream creates opportunities for technologies such as anaerobic digestion that can convert suitable organic waste into energy and other useful products.

Since the introduction of biogas technology to South Africa in 1957 by John Fry who built the country's first biogas digester on a pig farm using pig manure as feedstock approximately 700 digesters have been installed nationwide (Green Cape, 2024). By 1958, biogas was already being used to generate electricity to operate farm equipment such as pumps. However, despite this early start, the biogas sector in South Africa has seen limited growth. Factors contributing to this slow adoption include the low cost of electricity from conventional sources like fossil fuels, insufficient government subsidies or incentives for biogas development, and a lack of local technology providers. The situation began to shift in 2005 when the Central Energy Fund (CEF) initiated a bioenergy programme, prompted by several converging factors: the implementation of a renewable energy regulatory framework, the emergence of green financing and incentive schemes, increasing electricity tariffs, unreliable power supply, abundant untapped feedstock resources such as biomass and saturated landfill sites, and a growing need for cost-effective wastewater treatment. Additionally, although numerous small-scale household digesters have been deployed across the country, specific data on their numbers remain unpublished. In South Africa, many biogas digesters have been installed as individual demonstration units aimed at promoting awareness and encouraging wider adoption of the technology (Rasimphi et al., 2024). Biogas presents a renewable energy option particularly suited for thermal energy needs in rural communities, helping to address ongoing national energy challenges. Household decisions regarding energy sources are typically influenced by factors such as income levels, household size, and access to information. Among low-income households, traditional biomass particularly fuelwood remains a primary energy source, with more than 93% relying on it for domestic use.

South Africa has installed around 700 biodigesters, the majority of which operate at the small-scale domestic level (Mutungwazi et al., 2018). The future of biogas in South Africa presents significant opportunities for renewable energy generation, sustainable waste management, and local economic empowerment.

However, its adoption particularly in rural households remains limited. Estimates suggest that approximately 625,000 households (3.5% of all households nationally) in the country could benefit from this technology, yet uptake has been constrained by a range of challenges. These include gaps in policy and regulatory frameworks, technical limitations, insufficient funding, sustainability concerns, socio-cultural barriers, and a general lack of awareness and education (Kamusoko & Mukumba, 2025b). To unlock the full potential of biogas, South Africa's policy direction should prioritize enhancing economic viability, expanding funding mechanisms, incentivizing adoption, and investing in market research. Equally important is fostering active community participation and creating locally adapted waste-to-energy strategies aligned with global best practices. Achieving this will require a multi-actor approach that brings together government, the private sector, and communities to drive inclusive growth in the biogas sector.

Biogas technologies across different Provinces

Biogas research and deployment in South Africa show a clear provincial pattern, with activity concentrated in provinces where organic waste streams, livestock systems, municipal infrastructure, and institutional support make projects more feasible. The literature suggests that biogas remains a relatively undeveloped industry nationally, but provincial case studies demonstrate practical applications in both rural and urban settings (Trois, 2021).

GreenCape's business case notes 23 existing or planned biogas projects in the province, spanning dairy, fruit-processing, abattoir, landfill, and commercial applications (Gogela, 2017). This province is frequently used in the literature to show that project viability depends on large and reliable feedstock streams, strong on-site energy demand, and manageable digestate handling.

The KwaZulu-Natal literature is dominated by rural and household-scale systems. A major case study from Ndwedwe Local Municipality in iLembe District shows that micro-digesters can serve household energy, sanitation, and waste-management needs when they are matched with local conditions and supported by community engagement (Trois, 2021). However, the same study shows that operational failures, maintenance burdens, and socio-cultural factors can limit long-term adoption, even where feedstock is available.

In Limpopo, biogas research often focuses on household energy substitution and rural livelihoods. A desktop study in Vhembe District highlights the relevance of biogas for low-income households, especially where solid fuel use, indoor air pollution, and limited access to affordable modern energy remain important concerns. Rasimphi & Tinarwo (2020) emphasizes social benefits such as reduced firewood dependence and improved household energy security, but it also notes adoption barriers linked to maintenance, user practices, and system reliability.

The Free State appears in the literature mainly through livestock-based and farming applications. A study on household biogas digesters in Maluti-a-Phofung municipality found that biogas can be integrated into rural cattle-farming systems and used to replace grid electricity and other conventional fuels (Nape et al., 2019). The findings suggest that biogas is particularly relevant where manure is abundant and farms can directly use both gas and digestate, but financial viability remains sensitive to scale and local operating conditions.

Across provinces, the literature repeatedly identifies feedstock availability, project scale, and cost recovery as the main determinants of viability. In the Western Cape, the business case is strongest where biogas can offset high waste-disposal costs or significant on-site energy use, rather than relying only on electricity sales. In rural provinces such as KwaZulu-Natal and Limpopo, the literature frames biogas more as a decentralised development intervention than a purely commercial energy investment.

A second recurring theme is that technology success depends on local adaptation. The Ndwedwe case shows that digesters need design modifications, better gas-line management, and sanitation integration to work in rural conditions (Trois, 2021). Similarly, studies from farming communities in the Free State show that adoption improves when training, monitoring, and user support are built into the project from the start (Nape et al., 2019).

Overall, the literature shows that biogas in South African provinces is best understood as a geographically uneven but promising energy pathway. The Western Cape provides the strongest commercial and industrial evidence base, while KwaZulu-Natal, Limpopo, and the Free State offer important lessons on rural energy access, sanitation, and smallholder livestock systems.

Existing women and youth led Entrepreneurial initiatives in biogas sub sector in South Africa

The biogas subsector in South Africa, while relatively nascent compared to solar and wind energy, is increasingly emerging as a fertile space for inclusive entrepreneurship. Women and youth are playing significant roles as innovators, community mobilizers, and small-scale energy providers, particularly in rural and peri-urban areas where energy access and waste management challenges are most acute. Their entrepreneurial activities contribute not only to clean energy generation but also to local job creation, environmental management, and circular economy development. However, the scale of women's and young people's participation in South Africa's biogas subsector cannot currently be quantified reliably. The review undertaken for this scoping study did not identify a national dataset reporting either the number or percentage of biogas enterprises that are women-owned, women-led, youth-owned or youth-led. Available statistics on South Africa's renewable-energy, waste and SME sectors are not sufficiently disaggregated by technology, gender and age to produce such an estimate. This is particularly important because evidence that women and young people participate in the broader clean-energy economy cannot be used to infer their numerical representation within the much smaller biogas subsector.

The absence of these figures represents an important evidence and monitoring gap. It limits the ability to determine whether women and young people are benefiting from emerging business opportunities in biogas and to assess their participation across different parts of the value chain. It also reinforces the need for future enterprise mapping to collect information on ownership and leadership by gender and age, location, technology, enterprise size, employment and stage of commercial development.

Despite this national data limitation, the EVI-SICEE study identified two women- and/or youth-led enterprises operating in the biogas space in South Africa. These cases provide direct qualitative evidence that women and young entrepreneurs are participating in the subsector, although the two enterprises should not be interpreted as representing the total number operating nationally. Rather, they provide case-based evidence of the opportunities and challenges experienced by emerging entrepreneurs in a sector for which systematic enterprise data remain scarce. The cases highlight opportunities associated with community-based energy provision and organic-waste utilisation, while also identifying constraints such as limited finance, low consumer awareness of biogas technology, technical skills gaps, market development challenges and the need for stronger institutional and business-support networks. Further details on the two case studies are provided in Appendix 5.

This evidence suggests that biogas could provide additional pathways for women and young entrepreneurs to participate in South Africa's clean energy and circular economy. However, stronger conclusions about their overall representation require better national data. Establishing a database of clean energy enterprises disaggregated by technology, gender, age, province and enterprise size should therefore form part of efforts to monitor the inclusiveness of South Africa's clean energy transition.

His Grace Biogas Cooperative

One of the most notable youth-led initiatives in the biogas sector is the Tshilidzi Tshawe Biogas Cooperative, also known as His Grace Biogas Cooperative. This enterprise represents a community-centered model that integrates waste management, energy production, and agricultural productivity. Founded by a group of young entrepreneurs, the cooperative converts livestock manure, food waste, and agricultural residues into biogas for clean cooking and electricity generation.

The digestate produced through this process is repurposed as an organic fertilizer, supporting local smallholder farmers and enhancing soil fertility. This circular approach addresses multiple developmental challenges simultaneously reducing waste accumulation, providing affordable energy, and creating employment opportunities for local youth. The cooperative's business model emphasizes social enterprise principles, combining environmental sustainability with socio-economic empowerment. Their work demonstrates how biogas innovation can be localized to meet community energy needs while fostering youth leadership in South Africa's renewable energy transition.

Kaeane Renewable Energy Developers

Kaeane Renewable Energy Developers is a Lesotho-based clean energy enterprise and is included in this South African scoping study as a cross boarder CEE. Its inclusion provides relevant insights into youth-led biogas entrepreneurship, decentralised waste-to-energy technologies, and enterprise business models within the broader Southern African clean energy context. The case is therefore used to complement, rather than represent, evidence on women- and youth-led clean energy enterprises operating in South Africa.

The Kaeane Renewable Energy Developers initiative, has strong operational linkages with South African renewable energy programs through knowledge exchange, technical partnerships, and supply chain collaboration. The enterprise designs and installs bio-digester systems that convert organic waste into biogas for cooking, heating, and power generation, while also producing nutrient-rich liquid fertilizers for agricultural use. Kaeane Renewable Energy Developers operates on a hybrid social-enterprise model that blends community empowerment with technical innovation. The company has introduced fixed-dome (see Fig.9) and bio-septic systems that function as modern waste-to-energy solutions, particularly in rural and institutional settings such as schools and farms. These systems eliminate the need for costly septic tank maintenance while producing clean energy and fertilizer as valuable outputs.



Figure 9: Biogas digester under construction by Kaeane Renewable Energy Developers.

Source(<https://www.facebook.com/photo.php?fbid=1287469606721068&set=pb.100063741232030.-2207520000&type=3>)

Through partnerships with local municipalities, NGOs, and agricultural cooperatives, Kaeane has successfully promoted biogas adoption as both a climate mitigation tool and a livelihood strategy, creating income-generating opportunities for youth and women in rural economies. These initiatives collectively illustrate how localized biogas innovation, when supported by targeted capacity-building and financing mechanisms, can empower marginalized groups while contributing to South Africa's clean energy and waste management goals.

Box 1. What the enterprise case studies show about clean energy technology innovation

The EVI-SICEE case studies demonstrate that SME-level clean energy innovation in South Africa can involve both the development of new technologies and the adaptation or combination of existing technologies to address local needs. Amahlathi Eco-Tech illustrates energy-efficiency innovation through technologies designed to reduce electricity consumption associated with water heating. Kusini Water demonstrates the integration of solar PV with reverse osmosis and ultrafiltration technologies to provide decentralised water services in communities where electricity and safe water access may be constrained. The two biogas cases demonstrate opportunities to convert locally available organic and agricultural waste into useful energy and other outputs, including organic fertiliser. Collectively, the cases show that clean energy entrepreneurship is not limited to electricity generation. Technologies can form the basis of enterprises addressing interconnected challenges involving energy access, water security, waste management, agricultural productivity and resource efficiency. They also illustrate the importance of technologies that can be deployed at household, institutional and community scale, where SMEs may have more accessible opportunities to participate than in capital-intensive utility-scale renewable energy projects.

3.2.3 Clean cooking in South Africa

Clean cooking in South Africa is shaped by a mixed energy landscape in which households use electricity, LPG, paraffin, wood, and newer fuels such as ethanol gel, with adoption varying strongly by province and income group. Early sector mapping work showed that South Africa has a large potential market for advanced cooking solutions (see Fig.10), but that interventions need to be tailored to local energy access, settlement type, and provincial conditions rather than treated as nationally uniform. Accenture (2011) indicates that clean cooking is not driven only by health concerns; affordability, convenience, safety, fuel availability, and cultural cooking practices are often more important in household decision-making.

The absence of documented women- and youth-led clean cooking enterprise case studies should be interpreted as an important finding of the scoping review rather than as evidence that such enterprises do not exist in South Africa. Compared with the solar and biogas subsectors, the literature reviewed provides insufficient enterprise-level evidence to identify and analyse clean cooking businesses by ownership, age, business model, scale or commercial performance. South Africa's relatively high level of electrification and widespread use of electricity for cooking may partly explain the lower visibility of alternative clean cooking enterprises; however, significant differences in cooking-fuel use remain across provinces and socioeconomic groups. The clean cooking component of the study should therefore be regarded as exploratory, with the identified evidence gap providing a priority area for subsequent primary data collection under the EVI-SICEE project.

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LPG cooking

Liquefied Petroleum Gas (LPG) is widely discussed in the South African clean cooking literature as one of the most practical transition fuels because it is familiar, relatively clean-burning, and already present in urban and peri-urban markets. LPG is one of the alternative clean fuels currently available in South Africa and is increasingly recognized as a lower-emission substitute for conventional fossil fuels. Unlike natural gas, which consists primarily of methane, LPG is composed mainly of propane and butane. These gases are not classified as greenhouse gases because, being denser than air, they do not accumulate in the upper atmosphere as methane does. Although methane has a relatively short atmospheric lifetime of around 20 years, it has a substantially higher global warming potential than carbon dioxide over that period.

In comparison, LPG combustion produces approximately 85% of the carbon dioxide emissions generated by diesel fuel and emits fewer air pollutants than diesel, making it a cleaner fuel option (U.S. Energy Information Administration). However, LPG still produces approximately 15% more carbon dioxide during combustion than natural gas, indicating that while it offers environmental advantages over conventional liquid fuels, it remains a transitional rather than a zero-emission energy source (Clark et al., 2022). Despite its potential as a cleaner cooking and heating fuel, the adoption of LPG among low-income households in South Africa remains relatively limited. This is largely due to structural challenges related to distribution networks, market access, pricing, and regulatory frameworks, which contribute to the high cost of LPG for many households. Although the LPG industry has established standardized cylinders, efficient stove technologies, and regulated refilling systems, several barriers continue to hinder wider uptake. These include inadequate regulatory oversight and weak institutional capacity at the local level, particularly in rural and underserved communities. Additional challenges relate to the safe storage, handling, and transportation of LPG cylinders, the potential risk of accidents if safety standards are not observed, and the limited availability of refilling facilities in remote areas. Collectively, these constraints reduce the accessibility and affordability of LPG, limiting its contribution to South Africa's clean energy transition (Maré et al., 2023)

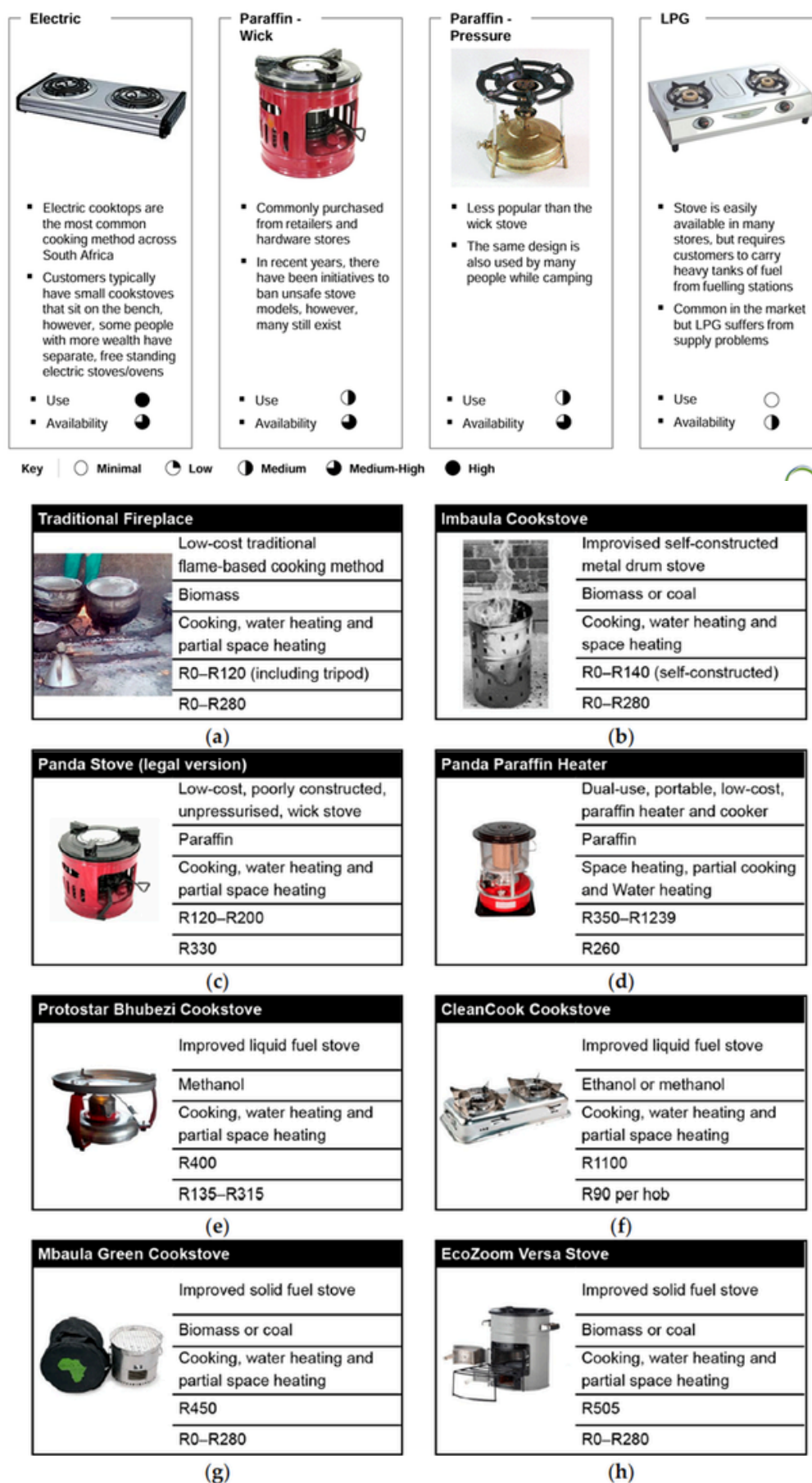


Figure 10: Cooking technologies used in South Africa. Source (Maré et al., 2023).

Electric pressure cookers

Electric pressure cookers are a newer clean cooking option in the South African context, but they fit the broader shift toward modern electric cooking in settings where households already have access to electricity (BGFA, 2021). Their main advantage is that they can cook energy-intensive meals such as legumes, stews, and starches efficiently, which is relevant in South African diets that often involve long-cooking foods. EPCs have strong potential because they reduce cooking time and can lower total cooking energy demand when electricity is available and tariffs are manageable (Efficiency for Access, 2021). For South African provinces, this suggests the strongest potential in more electrified and urbanized areas, especially where households already rely on electricity for cooking or have partial electric access.

Gel cookers and gel fuel

Gel cooking appears in the South African literature mainly through bio-ethanol gel fuel projects, especially municipal or demonstration-based interventions. The strongest documented example is the Umdoni Municipality project in KwaZulu-Natal, which provided bio-ethanol gel fuel (see Fig. 11) and gel-fuel cookstoves to rural households as part of a basic services initiative. The literature presents gel fuel as a cleaner and safer alternative to paraffin in some settings, but also notes weaknesses such as accidental poisoning risk, lower efficiency than some alternatives, and dependence on continued subsidy or project support (Marebane, 2021)



Figure 11: Methanol cookstove. Source (Marebane, 2021)

Cooking fuel use differs sharply by province, clean cooking strategies must reflect those differences. Energy use patterns in South Africa vary considerably between rural and urban areas. Rural households, particularly in provinces such as Limpopo and Mpumalanga, continue to depend largely on traditional and polluting fuels for cooking because of inadequate energy infrastructure, financial constraints, and limited access to affordable clean energy alternatives. In contrast, urban households in Gauteng, Western Cape, and Northern Cape generally have better access to electricity and higher income levels, enabling greater adoption of cleaner energy sources for household energy needs (Mofokeng & Mungatana, 2025). This provincial pattern matters because electric cooking technologies such as EPCs are more viable where electricity access is already high, while LPG and gel fuels may be more relevant where households need cleaner alternatives but cannot yet move fully to electric cooking. In contrast, rural provinces and poorer settlements still face stronger dependence on wood, charcoal, or paraffin, which means clean cooking interventions there often need to combine fuel access, affordability support, and behavior change.

A limitation identified in this scoping study is the absence of documented case studies on clean cooking enterprises, particularly those led by women and youth in South Africa[1]. This gap is largely attributed to the country's relatively high penetration of electricity for cooking, which reduces reliance on alternative clean cooking solutions such as improved cookstoves. As a result, there is limited visibility and documentation of scalable clean cooking business models, especially when compared to the more established solar and emerging biogas sectors. This highlights an important research and practice gap in understanding how clean cooking enterprises can be developed and supported within an energy context where electricity is the dominant cooking fuel.

3.3.Key actors in renewable energy sector in South Africa

South Africa's renewable energy sector is undergoing a major transformation, fuelled by evolving regulations, cutting-edge technologies, and rising demand for dependable clean power. Key players are leading the way in adapting to this dynamic environment and advancing sector growth. These include government and regulatory authorities that create policies and structures to support renewable energy expansion (Table 3). For those eyeing investments in South Africa's renewable energy market or planning renewable installations, it's crucial to grasp the organizations overseeing sector operations and the interplay among actors. Fig. 12 provides an overview of South Africa's electricity ecosystem.

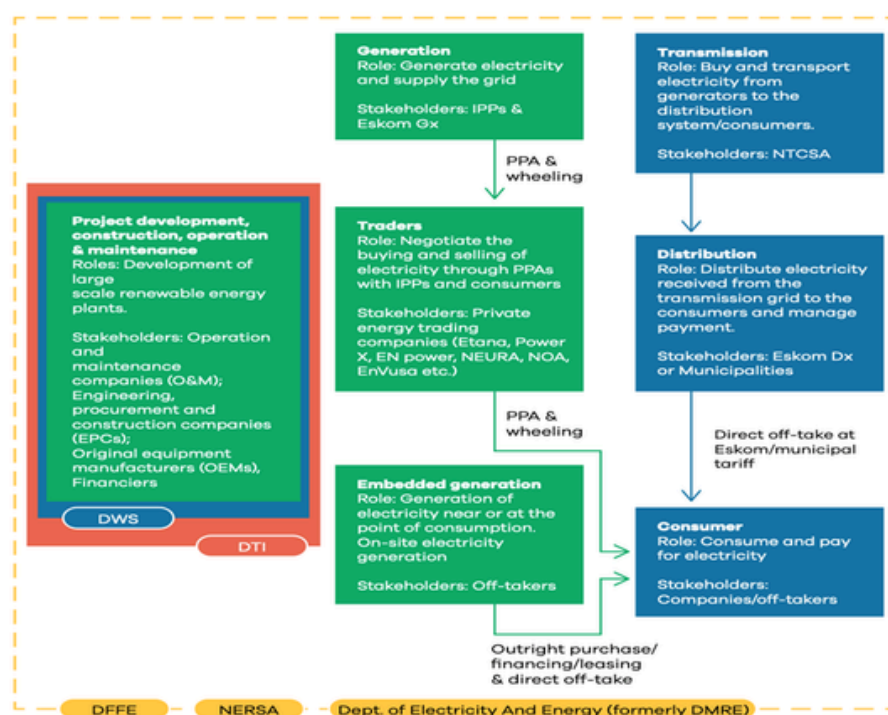


Figure 12: South African electricity landscape. Source (Rasimphi & Tinarwo, 2020).

Multiple institutions are involved in South Africa's energy sector, including Eskom, NERSA, and the National Transmission Company of South Africa (NTCSA), which oversee electricity generation, regulation, and transmission. Electricity distribution to end-users is largely managed by local municipalities, although some consumers receive power directly from Eskom. In addition, private sector actors such as Independent Power Producers (IPPs), Original Equipment Manufacturers (OEMs), Engineering, Procurement and Construction (EPC) contractors, and energy traders play significant roles in project implementation and electricity markets. Further details on key actors are presented in Table 4, which outlines the main government and regulatory bodies in the renewable energy sector in South Africa.

[1] This limitation will be mitigated through survey data which will be used to supplement the data on clean cooking in Guateng province.

Table 4: Key actors in the clean energy ecosystem in South Africa. Source (DMRE, 2023; IEA, 2024; T. E. Rasimphi & Tinarwo, 2020).

Category	Actor	Role in the Clean Energy Sectoral Innovation System
Government	Department of Electricity and Energy (DEE)	Leads the development and implementation of national energy policies aimed at ensuring secure, affordable and sustainable energy while promoting energy security, renewable energy deployment, and grid stability. Oversees implementation of the Integrated Resource Plan (IRP) and REIPPPP.
	National Energy Regulator of South Africa (NERSA)	Regulates the electricity sector by issuing licences for electricity generation, transmission and distribution, approving electricity tariffs, and establishing the regulatory framework governing electricity markets.
	Department of Forestry, Fisheries and the Environment (DFFE)	Develops and enforces environmental legislation and environmental impact assessment (EIA) requirements to ensure renewable energy projects comply with sustainability and environmental protection standards.
	Grid Operators and Energy Distributors (Eskom & Municipal Utilities)	Manage electricity transmission and distribution infrastructure, integrate renewable energy into the national grid, maintain network stability, and deliver electricity to consumers.
	Independent Power Producers (IPPs)	Develop, finance, construct, own and operate renewable energy generation projects. Responsible for project development, securing finance, land acquisition, bidding under REIPPPP, and negotiating power purchase agreements (PPAs).
	Engineering, Procurement and Construction (EPC) Companies	Design, procure, construct and install renewable energy facilities, managing projects from engineering design through commissioning and installation.
Financial organizations and Investors	Commercial banks, development finance institutions (e.g., IDC, DBSA), venture capital firms and climate finance providers.	They provide loans, grants, equity investment and blended finance for renewable energy projects and enterprise development.
Research organizations and Universities	Institutions such as the CSIR, SANEDI and universities support technology transfer and enterprise innovation.	Conduct research and development (R&D), technology demonstration, innovation, skills development and knowledge generation.
Innovation intermediaries	Organisations such as the Technology Innovation Agency (TIA), Small Enterprise Development Agency (SEDA), GreenCape, incubators and accelerators	Provide business incubation, commercialization support, mentorship, technical assistance and entrepreneurship development.
Development Partners and International Organisations	Organisations such as GIZ, UNDP, SeforALL, IRENA and donor agencies	Provide technical assistance, policy support, funding, capacity building and knowledge exchange to strengthen South Africa's clean energy ecosystem.
Clean Energy Enterprises	Youth- and women-led Clean Energy Enterprises	Central innovation actors that develop, adapt and commercialise clean energy technologies and business models in areas including solar PV and biogas technologies.
Public/ civil society	Communities, Municipalities and Civil Society Organisations	Facilitate local implementation, community participation, awareness creation and adoption of renewable energy technologies. They play an important role in building social acceptance and ensuring inclusive and equitable energy

3.4. Systemic barriers affecting women-led and youth-led CEEs in South Africa

Despite the growing recognition of women and youth as key actors in advancing South Africa's clean energy transition, systemic barriers continue to hinder their full participation and scalability in the renewable energy ecosystem (UN Women, 2023). Evidence from multiple studies reveals that structural, financial, policy, and socio-cultural constraints limit the ability of youth- and women-led enterprises to establish, grow, and compete within the clean energy sector. These barriers are especially pronounced in SMEs engaged in solar, biogas, and other renewable energy value chains, where capital intensity, regulatory uncertainty, and entrenched gender inequities persist.

Older and more established male-led SMEs may also experience difficulties accessing finance, navigating regulation and certification, recruiting skilled workers and entering established markets. The distinction lies in the resources, networks, experience and institutional legitimacy that entrepreneurs can draw upon to navigate these constraints. Older and more established male entrepreneurs are more likely to have had time to accumulate business assets, credit histories, industry experience, professional relationships and established customer and supplier networks. Women and young entrepreneurs may enter the same ecosystem with fewer of these accumulated resources, while women can additionally encounter gendered assumptions about entrepreneurial and technical competence and exclusion from male-dominated business networks. Research on women's entrepreneurial finance and networking demonstrates that gender can influence access to capital, networks and legitimacy, while research on youth entrepreneurship highlights limited collateral, credit history and business track records as important barriers (Brush et al., 2019; Pettersen et al., 2026).

The issue is therefore not simply whether a barrier exists, but who is better positioned to overcome it. From an inclusive innovation systems perspective, formally identical market and institutional conditions can produce unequal outcomes because entrepreneurs differ in their access to financial, social, knowledge and institutional resources. Women and young entrepreneurs may consequently require more time, support and resources to overcome barriers that better-established entrepreneurs can navigate through accumulated capital, experience and networks.

South Africa-specific empirical literature focusing explicitly on women- and youth-led clean energy enterprises remains limited. Consequently, the analysis of systemic barriers in this section draws on two complementary bodies of evidence. The first comprises clean-energy-specific studies and reports, including research on renewable-energy SMEs, clean energy financing, solar and biogas value chains, and gender participation in the sustainable energy transition. The second comprises broader South African SME and entrepreneurship literature, particularly studies examining women entrepreneurs, youth-owned SMEs and general SME financing, skills, market access and regulatory constraints. Findings from the broader SME literature are used to provide contextual evidence on barriers that are likely to affect clean energy entrepreneurs but should not, in the absence of sector-specific evidence, be interpreted as direct empirical findings on women- and youth-led CEEs.

1. Financial constraints and limited access to capital

A key barrier to the participation of women and youth entrepreneurs in CEEs is restricted access to finance. However, because many of these SMEs are in the early stages of development, they are often considered high-risk by financial institutions, making it difficult for them to secure conventional financing. Although national development finance institutions and commercial banks are increasingly able to access climate and green finance, many lack the capacity, expertise, and appropriate mechanisms to develop a strong pipeline of investment-ready SMEs engaged in the energy transition (REEEP, 2026). Women entrepreneurs in particular face gender-based financial discrimination, including higher collateral requirements and limited access to formal financial networks (Irene et al., 2025). Women-owned businesses receive significantly less venture capital and investment funding compared to male-led enterprises, reflecting both systemic gender biases and structural inequities in financial markets (UNIDO, 2022). Youth-led enterprises encounter similar financial exclusion, often compounded by their lack of credit track records and business collateral, making them ineligible for commercial loans (Matlhake & Kalitanyi, 2025a). As a result, many young entrepreneurs rely on informal or community savings schemes, which are insufficient for the capital-intensive renewable energy sector. Furthermore, limited financial literacy and poor awareness of alternative instruments such as venture capital, crowdfunding, and blended finance further restrict access to investment.

Access to finance is a constraint across South Africa's SME sector and should therefore not be presented as unique to women- and youth-led CEEs. The difference concerns entrepreneurs' ability to satisfy financing requirements and absorb financial risk. Older, established male entrepreneurs may be more likely to have accumulated personal or business assets, longer credit and trading histories, established banking relationships and previous business performance that can be used to demonstrate creditworthiness. Young entrepreneurs, by definition, have had less time to accumulate these resources and may have shorter credit histories, fewer assets that can serve as collateral and less extensive investor relationships. [South Africa's draft Integrated Youth Development Strategy 2026–2029](#), for example, explicitly identifies collateral and limited track records as constraints affecting youth access to enterprise finance. Consequently, a financing system based heavily on collateral, previous turnover, established credit histories and investor networks may appear gender- and age-neutral while producing unequal outcomes among entrepreneurs who enter the system with different levels of accumulated financial capital.

2. Regulatory barriers

Regulatory bottlenecks remain one of the most persistent obstacles for small renewable energy enterprises. The lack of a coherent and enabling policy framework for small-scale embedded generation (SSEG) constrains growth and innovation (Machingambi & Rankhumise, 2026). Entrepreneurs face difficulties in obtaining permits and grid-connection approvals, particularly for systems exceeding 100 kW. This uncertainty discourages private investment and limits market entry for emerging youth- and women-led businesses.

Additionally, inconsistent implementation of renewable energy standards, coupled with bureaucratic delays and high compliance costs, disproportionately affect smaller firms. The absence of clear technical standards, quality assurance frameworks, and certification systems also undermines consumer confidence and increases risk exposure for small enterprises (Murombo, 2016). Women-led businesses are particularly disadvantaged by non-gender-responsive energy policies that fail to account for their unique financial, social, and operational constraints. Many government incentive programs and procurement frameworks remain gender-neutral in design but gender-biased in effect, as they favor larger, established companies that can meet complex bidding and technical requirements (UN Women, 2023).

Regulatory requirements, certification costs, licensing and procurement procedures affect CEEs irrespective of the owner's gender or age. However, their consequences may be more severe for younger and women-led enterprises where firms are smaller, newer or have fewer financial and human resources available to manage compliance. A long-established enterprise may be better positioned to employ specialist compliance staff, finance certification costs, absorb administrative delays or draw on established relationships with regulators and industry actors. Newer women- and youth-led enterprises may have to navigate the same processes with fewer internal resources and less institutional experience. The EVI-SICEE scoping study findings therefore suggest that regulatory inclusion should not mean reducing technical or safety standards for women and youth. Rather, it means ensuring that the pathway to meeting those standards is transparent, affordable and accessible, including access to technical guidance, testing facilities, certification finance and institutional support.

3. Skills shortages and limited technical capacity

The shortage of technical and entrepreneurial skills among women and youth significantly limits their participation in the clean energy sector (Kruger, 2024). According to IRENA (2025), women remain underrepresented in technical and engineering roles within the renewable energy sector, accounting for less than one-third of the workforce and an even smaller share in leadership and design positions.

Many youth entrepreneurs also lack access to hands-on technical training and mentorship, which limits their ability to innovate, manage, and maintain clean energy systems effectively. This skills gap extends to business management and marketing, with both women and youth entrepreneurs reporting limited access to entrepreneurship development programs and incubators that are tailored to clean energy innovation (Matlhake & Kalitanyi, 2025b). Consequently, even well-intentioned start-ups often struggle to scale operations or attract investment.

Skills shortages are similarly sector-wide rather than unique to women and youth. The difference again concerns access to opportunities through which technical and entrepreneurial capabilities are accumulated. Older entrepreneurs may have had longer periods in employment, business or industry through which to develop technical knowledge, management experience, customer relationships and sector-specific knowledge. Young entrepreneurs have necessarily had less time to accumulate such experience and may therefore depend more heavily on mentorship, incubation, technical training and university or research partnerships. For women, the issue is also shaped by historical underrepresentation in technical and engineering fields. This can reduce access to technical professional networks, experienced mentors and opportunities to establish credibility within traditionally male-dominated parts of the energy industry. Skills development for women and youth should therefore address not only technical training but also access to mentorship, professional networks, commercialisation capabilities and opportunities to demonstrate technical competence.

4. Market access and participation gaps

Barriers to market access continue to marginalize women and youth entrepreneurs in renewable energy value chains. According to UN Women (2025), women-led enterprises frequently lack the networks, logistical capacity, and market visibility necessary to reach customers and suppliers, particularly in rural and peri-urban areas in South Africa. Challenges such as high transportation costs, restricted mobility, and limited access to distribution channels exacerbate their exclusion from competitive markets. Furthermore, limited participation in public procurement and corporate supply chains undermines the growth potential of women-owned CEEs. Tendering processes often impose complex documentation, high advance payment requirements, and stringent technical qualifications, effectively excluding small-scale and informal women entrepreneurs. Youth enterprises, meanwhile, face barriers to entering established markets dominated by larger, foreign-owned companies, leaving them dependent on low-value local contracts or community-level installations (Matlhake & Kalitanyi, 2025a).

Accessing customers, procurement opportunities and established supply chains is difficult for many small CEEs. Older and established entrepreneurs, however, may have accumulated customer relationships, supplier networks, industry contacts and reputational capital over longer periods. Young entrepreneurs generally enter markets without comparable track records, while women entrepreneurs may additionally encounter gendered barriers in accessing influential networks. Pettersen et al. (2025) show that women opportunity entrepreneurs navigate entrepreneurial networks within an intersectional environment in which access to social and business networks matters for opportunity development. This helps explain why apparently informal mechanisms; industry relationships, referrals, introductions and networking spaces, can produce structural differences between entrepreneurs. Formal innovation networks, industry associations, incubation programmes and procurement platforms can therefore provide alternative pathways through which women and young entrepreneurs build relationships, credibility and market access.

5. Socio-cultural and gender norms

Traditional gender expectations such as domestic responsibilities and mobility constraints limit women's participation in field-based or engineering-intensive roles, reducing their exposure to high-growth opportunities in solar and biogas sectors (UN Women, 2023). According to (Matlhake & Kalitanyi, 2025a), youth entrepreneurs encounter social barriers linked to limited intergenerational trust, lack of mentorship, and exclusion from decision-making networks. These factors reinforce a cycle of underrepresentation, where women and youth remain at the periphery of South Africa's clean energy innovation ecosystem.

South Africa's transition to a low-carbon energy system is taking place within a context of longstanding gender inequalities that have historically limited women's participation in the energy sector (Geen, 2025). Socio-cultural norms continue to shape the gendered landscape of entrepreneurship in South Africa's energy transition. The clean energy sector has traditionally been male dominated, women continue to face barriers related to unequal access to employment, decision-making, finance, technical skills, and professional networks. Consequently, many women remain excluded from the knowledge, resources, and opportunities needed to participate effectively in the emerging clean energy economy. Jenkins et al. (2016) argue that inclusive energy transitions depend on three key mechanisms: the integration of local knowledge, effective information sharing, and meaningful institutional representation. However, opportunities for women to influence energy policy and decision-making remain limited. Although the National Economic Development and Labour Council (NEDLAC) provides a platform for actor engagement, its processes are largely dominated by business and labour interests, with limited representation of women-led enterprises and grassroots actors.

This is where the difference from older male-led enterprises is most pronounced. Unlike finance or regulatory compliance, gender discrimination is not a barrier experienced symmetrically by male- and women-led businesses. Women entrepreneurs can encounter stereotypes about their technical competence, leadership capacity and credibility within sectors historically dominated by men. They may also have less access to informal networking spaces through which information, partnerships and commercial opportunities circulate. Older male entrepreneurs operating within these environments may therefore benefit not simply from age and experience, but from greater alignment with historically established professional and industry networks. This does not mean that all older men are advantaged or that all women experience the same barriers. Rather, gender, age, race, class, location and previous professional experience can intersect to influence entrepreneurs' access to resources and opportunities. This intersectional understanding avoids treating "women," "youth" and "older men" as homogeneous categories.

Without deliberate efforts to address these structural inequalities, South Africa's decarbonisation agenda risks reinforcing existing patterns of exclusion, leaving women underrepresented in the benefits of the clean energy transition. Integrating gender considerations into energy policies and programmes through gender mainstreaming can help ensure that women and men have equitable access to opportunities, resources, and decision-making processes (Clancy, 2025). Despite growing recognition of the importance of inclusive energy transitions, gender mainstreaming remains insufficiently embedded in many energy policies and institutional practices, limiting the transformative potential of South Africa's clean energy transition (Geen, 2025).

6. Structural and supply chain challenges

A recurring structural barrier identified across studies relates to the import dependency of renewable energy components, particularly in solar and biogas technologies.

The limited local manufacturing base constrains opportunities for small enterprises to participate in supply chains, resulting in a “missing middle” where women and youth entrepreneurs operate mainly as retailers or installers rather than manufacturers (Peters & Naicker, 2013). The inability to establish localized production also stifles job creation and weakens South Africa’s potential for inclusive industrialization within the clean energy sector (Ettmayr & Lloyd, 2017).

Additionally, high equipment costs and foreign currency fluctuations increase market risks for small businesses, particularly those without access to foreign exchange credit or bulk purchasing agreements. Enterprises with larger balance sheets, established supplier relationships and access to bulk purchasing or trade finance are better positioned to manage these risks. Women- and youth-led firms that are newer or smaller may have less purchasing power and fewer established relationships with manufacturers and distributors. They may therefore remain concentrated in lower-entry-barrier activities such as installation, distribution and local service provision rather than entering more capital-intensive segments of the value chain. The relevant inequality is therefore not simply participation in clean energy, but the position enterprises occupy within the value chain and their ability to move into higher-value activities.

7. Institutional gaps in support systems

Institutional support for women and youth in clean energy entrepreneurship remains fragmented and insufficiently coordinated. While initiatives such as the Just Energy Transition framework provide enabling foundations, many support mechanisms remain underfunded or disconnected from grassroots enterprises (Rasimphi et al., 2025). Studies indicate a lack of targeted mentorship, incubation, and business advisory services for early-stage CEEs (Mgweba & Lungisa, 2024). Moreover, limited integration between local governments, development finance institutions (DFIs) (Sesele, 2025), and innovation hubs reduces the potential for scaling successful youth-and women-led models. Without coherent institutional backing, the growth of inclusive renewable energy entrepreneurship remains constrained.

Fragmented institutional support can affect all SMEs, but entrepreneurs with extensive business experience and professional networks may be better able to identify the appropriate institution, navigate programmes and mobilise assistance independently. Women and young entrepreneurs with weaker institutional networks may depend more heavily on incubators, universities, innovation intermediaries, mentors and enterprise-support organisations to connect them with finance, technical expertise and markets. This makes institutional coordination particularly important for inclusive enterprise development. Incubation and partnerships can perform a compensatory role, helping women- and youth-led CEEs overcome gaps in resources, experience, credibility and networks that more established entrepreneurs may already possess.

The findings therefore suggest that the systemic barriers confronting women- and youth-led CEEs should not be understood as an entirely separate set of challenges from those affecting other South African SMEs. Finance, regulatory complexity, certification, skills shortages, weak markets and supply-chain constraints can affect enterprises regardless of the entrepreneur's gender or age. What differs is entrepreneurs' capacity to navigate and absorb these barriers. Older and more established male-led enterprises may, on average, have had greater opportunity to accumulate financial assets, business track records, sector experience, customer relationships and professional networks. Young entrepreneurs have had less time to accumulate these forms of capital, while women may additionally encounter gendered barriers relating to credibility, technical legitimacy, care responsibilities and participation in male-dominated networks. These disadvantages can also intersect with race, location and socio-economic background.

Consequently, apparently gender- and age-neutral institutions can generate unequal outcomes when entrepreneurs enter the system from unequal starting positions. This distinction has important implications for South Africa's clean energy transition. An inclusive innovation system should therefore be assessed not only by whether finance, skills programmes, procurement opportunities, incubation and networks exist, but also by who can access them, under what conditions, and whether they help reduce existing inequalities in access to resources, knowledge, markets and decision-making power. Targeted support for women- and youth-led CEEs should therefore not be understood as preferential treatment, but as a mechanism for addressing structural differences in entrepreneurs' capacity to access and benefit from the clean energy innovation system.

Clean-energy-specific evidence indicates that clean energy SMEs face high capital requirements, stringent lending criteria and difficulties obtaining finance appropriate to their stage of development (Mkhwebane & Ntuli, 2019). These sector-specific findings are consistent with the broader South African SME literature, which identifies collateral requirements, limited financial histories and restricted access to external finance as persistent constraints on SME development. Evidence from the broader South African youth entrepreneurship literature, rather than clean-energy-specific studies, indicates that youth-owned SMEs commonly experience financing constraints, limited business track records, bureaucratic challenges and gaps in entrepreneurial education (Matlhake & Kalitanyi, 2025a).

These findings provide relevant contextual evidence for understanding the circumstances facing young clean energy entrepreneurs, although further sector-specific empirical research is required to establish how these barriers operate within clean energy value chains. Evidence specific to women in sustainable and clean energy sectors identifies financing gaps, unequal market access, limited mentorship and gender-related institutional constraints. These findings are reinforced by the broader women's entrepreneurship literature in South Africa, which similarly identifies access to finance and business networks as important constraints. The convergence between the two evidence bases strengthens the relevance of these barriers, while the limited number of clean-energy-specific studies warrants caution in generalising their magnitude across the CEE population.

3.5. Financing mechanisms for women- and youth-led SMEs in South Africa

Access to appropriate finance remains a major constraint for women- and youth-led SMEs in South Africa. Conventional SME lending frequently depends on collateral, credit histories, financial statements, demonstrated turnover and business track records. These requirements can particularly disadvantage young entrepreneurs, who have had less time to accumulate assets and credit histories, and women entrepreneurs, whose access to collateral, financial networks and entrepreneurial finance may be constrained by wider structural inequalities (Leonard et al., 2026; Machingambi & Rankhumise, 2026). These constraints are particularly relevant for CEEs, where entrepreneurs may require capital for technology development, equipment, testing and certification, demonstration projects, working capital and eventual commercial expansion.

South Africa has established a range of targeted and broader development-finance mechanisms that can support women- and youth-led enterprises. These include grants, concessional and development finance, debt and equity instruments, as well as emerging blended-finance mechanisms. Their relevance differs according to the stage of enterprise development.

Target finance mechanisms for women- and youth-led enterprises.

- provides one of South Africa's most direct youth-enterprise financing mechanisms through its Grant Programme. The programme targets South African youth entrepreneurs between 18 and 35 years of age and combines financial assistance with non-financial business-development support. Grant-based financing is particularly important for young entrepreneurs because it can reduce dependence on collateral-based commercial debt during the early stages of enterprise development. For youth-led CEEs, such support can potentially contribute towards acquiring productive assets and establishing or developing an enterprise before it has accumulated the financial history required by conventional lenders.
- (Matlhake & Kalitanyi, 2025), provides another mechanism specifically intended to support youth-owned enterprises. Established through South Africa's small-business development framework, the YCF combines financial support with business-development assistance for qualifying youth-owned enterprises (Republic of South Africa, 2026). This combination is relevant to youth-led CEEs because financing constraints frequently occur alongside capability gaps in financial management, investment readiness and business development.
- Industrial Development Corporation (IDC), also provides development-finance instruments that can support youth entrepreneurship and historically disadvantaged entrepreneurs. Development finance can become particularly important when an enterprise progresses beyond the relatively small amounts normally associated with start-up grants and requires larger amounts of capital for equipment, production, technology commercialisation and expansion (IDC, 2014).
- National Empowerment Fund (NEF) Women Empowerment Fund (WEF). The WEF was established specifically to support businesses owned and managed by Black women and provides funding through instruments that can include debt, equity and quasi-equity. Unlike conventional commercial lending based primarily on collateral, development-finance structures can be adapted to the financing requirements and growth potential of qualifying enterprises (World Bank, 2018). This makes the mechanism potentially relevant to women-led CEEs requiring capital for equipment, production capacity, working capital and commercial expansion.

Broader finance mechanisms for women- and youth-led enterprises.

Broader development-finance institutions can also play an important role. Financing delivered through South Africa's small-enterprise development-finance system is intended to expand access to capital among SMEs that may struggle to obtain conventional bank finance. For women-led CEEs, however, the existence of these mechanisms does not necessarily guarantee access. Machingambi & Rankhumise, (2026) identify finance as a significant constraint and emphasises the importance of financial mechanisms that address collateral requirements alongside business-development and capacity-building support.

- **Blended finance and credit-risk mechanisms.** For CEEs moving from technology development to commercialisation, blended finance provides another important mechanism. Blended-finance arrangements combine public, development or philanthropic capital with private investment in order to reduce investment risk. Instruments may include grants combined with commercial loans, concessional debt, guarantees, first-loss capital and co-investment arrangements (Convergence, 2024). Such mechanisms are particularly relevant to emerging women- and youth-led CEEs because they can reduce some of the risks that discourage commercial financiers from investing in businesses with limited collateral or short trading histories. Ahmad et al. (2025) highlights that concessional and de-risking finance can help address financing gaps faced by emerging green enterprises. Kingiri et al. (2026) similarly argues for financing models that combine different instruments and respond to enterprises' changing requirements as they move from start-up through commercialisation to scaling.

- **Equity and venture-capital finance.** Venture capital and other forms of equity investment provide another potential source of finance for innovative CEEs with significant growth potential. Unlike conventional loans, equity financing does not necessarily require entrepreneurs to provide physical assets as collateral. This can make it suitable for technology-oriented businesses whose principal assets may initially consist of intellectual property, technology and entrepreneurial capabilities. Nevertheless, equity finance should not automatically be assumed to be inclusive. According to Leonard et al. (2026) persistent gender disparities exist in entrepreneurial finance and venture-capital investment. Dedicated gender-lens investment funds and investment criteria that recognise different entrepreneurial starting positions can therefore be important for increasing women's participation in clean-energy investment opportunities.
- **Fintech, crowdfunding and alternative finance.** Digital financial services, crowdfunding and fintech-based lending offer additional mechanisms that may help address some limitations of conventional SME lending (Sanga & Aziakpono, 2023). Alternative credit-scoring systems can potentially use transaction and other business data rather than relying exclusively on physical collateral and long-established credit histories (Sirtaine, 2025). This may benefit younger and women entrepreneurs who operate viable businesses but have limited conventional collateral. However, these mechanisms remain complementary to, rather than substitutes for, development finance, grants and commercial investment for capital-intensive CEEs.

Overall, the financing needs of women- and youth-led CEEs extend beyond initial start-up capital. Enterprises require different financing instruments as they move through the innovation and scaling process. Existing mechanisms such as NYDA youth grants, the Youth Challenge Fund, the NEF Women Empowerment Fund and development finance provided through institutions such as the IDC provide important entry points. However, stronger coordination between these mechanisms and clean-energy incubation, technical validation, certification and market-development programmes is required. For women- and youth-led CEEs, the key issue is therefore not only whether finance exists, but whether the type, scale, eligibility requirements and timing of finance correspond to the enterprise's stage of development and its capacity to meet conventional financing requirements.

3.6. Business models in for women- and youth-led SMEs in South Africa

Women- and youth-led CEEs in South Africa can participate in the clean energy ecosystem through a range of business models rather than through a single model of technology ownership or production. These models determine what value an enterprise provides, who its customers are, how products and services are delivered, and how the enterprise generates revenue. Across Africa, clean-energy entrepreneurship encompasses product sales, installation and maintenance services, leasing and pay-as-you-go arrangements, energy-service models, community and cooperative enterprises, and circular-economy models that convert waste into energy and other marketable products (Kusemererwa & Elasu, 2026). For women and young entrepreneurs, the choice of business model is particularly important because high capital requirements can make ownership of large-scale generation assets or manufacturing facilities difficult. Business models based on installation, distribution, services, partnerships, decentralised technologies and community-level delivery can provide relatively more accessible entry points into clean-energy value chains. However, the ability to move from these entry points into higher-value activities depends on access to finance, technology, skills, certification, networks and markets.

1. Product sales, installation and maintenance model

One of the most accessible business models for smaller CEEs involves the sale, installation, maintenance and repair of clean-energy technologies.

Enterprises generate revenue by supplying equipment and charging customers for installation, maintenance, technical support and related services. In the solar sector, this can include PV panels, inverters, batteries, solar water-heating systems and associated electrical services. Similar service-based opportunities exist around biodigesters and other decentralised clean-energy technologies. This model can be particularly relevant for women and young entrepreneurs because it does not necessarily require the enterprise to manufacture technologies or own large generation assets. It can therefore provide an entry point into the clean-energy value chain with comparatively lower capital requirements. However, scaling requires technical certification, skilled personnel, reliable suppliers, working capital and customer trust. Recent literature on energy entrepreneurship confirms the importance of SMEs in delivering decentralised renewable-energy technologies and associated services to households, businesses and rural communities (Kusemererwa & Elasu, 2026). The Kaeane Renewable Energy Developers case in the EVI-SICEE study illustrates this type of model, with the youth-led enterprise providing solar-energy systems and services to households, businesses and public institutions.

2. Technology development and commercialisation model

A second model involves entrepreneurs developing an innovative clean-energy or energy-efficiency technology and subsequently commercialising it through direct sales, licensing, partnerships or distribution networks. In this model, the enterprise's competitive advantage lies in the technology or product it has developed rather than simply distributing an existing product. This model is illustrated by Amahlathi Eco-Tech (AET Africa), a women-led South African enterprise developing energy-efficiency technology, including its HotSpot geyser sleeve. The enterprise's experience demonstrates both the potential and challenges of technology-based entrepreneurship. Moving from product development to commercial scale requires research and development, testing, technical validation, certification, manufacturing or production capability, finance and access to markets. This model can be particularly difficult for women- and youth-led CEEs because substantial investment may be required before commercial revenues are generated. Universities, public research organisations, incubators and innovation agencies can therefore play an important role in providing technical validation, research facilities, mentorship and commercialisation support. African green-innovation research similarly finds that enterprises frequently require ecosystem support to bridge the gap between innovation and commercial scale (Startinev, 2025).

3. Energy-as-a-service and fee-for-service models

Rather than requiring customers to purchase expensive energy equipment outright, an energy-as-a-service or fee-for-service model allows customers to pay for the energy service provided. The enterprise may retain ownership of the equipment and recover its investment through recurring payments, service fees or contracts. For example, instead of selling a solar system outright, an enterprise can install and maintain the system while the customer pays a monthly service charge or pays according to energy consumption. This reduces the customer's initial capital burden and creates a recurring revenue stream for the enterprise. Reviews of African clean-energy business models identify fee-for-service arrangements as mechanisms for expanding access where customers cannot afford the full upfront cost of renewable-energy equipment (Mukoro et al., 2022). For women- and youth-led CEEs, the model creates opportunities to develop longer-term relationships with customers rather than relying exclusively on once-off equipment sales. Its limitation, however, is that the enterprise itself requires sufficient upfront capital to purchase and install the equipment before recovering costs over time. Access to patient capital and asset finance is therefore particularly important.

4. Pay-as-you-go and lease-to-own models

Pay-as-you-go (PAYG) and lease-to-own models reduce the upfront cost of clean-energy technologies by allowing customers to make payments over time.

Under PAYG, payments can be linked to usage or predetermined instalments, often supported by digital payment technologies. Under lease-to-own arrangements, ownership of the equipment is transferred to the customer after completion of an agreed payment period. These models have become particularly prominent in African decentralised-energy markets because they combine energy technology with consumer finance. Recent reviews identify PAYG and lease-to-own arrangements among the innovative business models used to extend decentralised energy services to lower-income and rural consumers (Kusemererwa & Elasu, 2026). Such approaches potentially create opportunities for women- and youth-led CEEs to reach customers who cannot afford large upfront payments. However, they transfer some financing risk to the enterprise. Entrepreneurs therefore need access to working capital, digital payment systems, customer-credit assessment and financing partners. Partnerships with banks, fintech companies, development-finance institutions and impact investors can consequently become central components of the business model.

5. Business-to-business and institutional contracting model

Women- and youth-led CEEs can also generate revenue through business-to-business (B2B) and business-to-government/institutional contracts, rather than relying solely on individual household customers. Potential clients include commercial businesses, farms, schools, universities, municipalities, hospitals and other public institutions. For example, a solar enterprise may design, install and maintain systems for commercial or municipal clients, while a water-energy enterprise may provide solar-powered water-treatment infrastructure under contracts with municipalities, corporations or development organisations. Larger institutional contracts can provide enterprises with more substantial and predictable revenue than individual retail transactions. The Kusini Water case illustrates the importance of this type of partnership-oriented model. Its solar-powered water solutions have involved relationships with private-sector organisations and municipalities. Such arrangements demonstrate how strategic partnerships can become part of the enterprise's business model by providing access to customers, finance, demonstration sites and markets. For women and young entrepreneurs, however, institutional contracting can be difficult to access because procurement processes may require previous contracts, substantial working capital, technical certification and established business records (Mutangili, 2025). Delayed payments can also create serious cash-flow problems for smaller CEEs.

6. Community-based and cooperative business models

Community and cooperative models provide another important pathway for women and youth participation, particularly in rural and underserved communities. Rather than organising the enterprise solely around individual ownership and conventional product sales, community members can participate in technology deployment, operation, maintenance, resource collection or benefit sharing. Recent systematic-review evidence identifies cooperatives and social-enterprise models among the business approaches through which energy entrepreneurship can support rural development (Kusemererwa & Elasu, 2026). These models can be particularly relevant to biogas, biomass, mini-grid and other decentralised technologies that depend on locally available resources and community participation. The Tshilidzi Tshawe (His Grace) Cooperative identified by EVI-SICEE provides a South African example. Its community-oriented biogas activities demonstrate how organic and agricultural waste can potentially become an input into local energy provision while generating associated livelihood and enterprise opportunities. Cooperative models may lower individual entry barriers by pooling resources, knowledge and labour. However, their sustainability depends on effective governance, technical capability, reliable revenue streams and continued community participation (Van Opstal et al., 2025).

Implications for women- and youth-led CEEs

These business models demonstrate that participation in the clean-energy ecosystem extends beyond owning large clean-energy projects. Women and young entrepreneurs can enter the sector as technology developers, equipment suppliers, installers, maintenance providers, energy-service companies, waste-to-energy enterprises, cooperatives and community-based energy providers. However, not all models have the same entry requirements or scaling potential. Direct sales and installation may provide relatively accessible entry points but can leave enterprises operating in lower-value parts of the supply chain. Technology commercialisation, energy-as-a-service and PAYG models can generate stronger recurring revenue or greater value capture but require substantially more finance, technical capability and institutional support. Community and cooperative models can improve inclusion but require strong governance and viable revenue streams. For South Africa, the policy challenge is therefore not simply to encourage more women and young people to establish CEEs, but to enable them to develop commercially viable and scalable business models. This requires aligning business-model development with incubation, appropriate finance, technical validation and certification, digital technologies, strategic partnerships, procurement opportunities and market development. In particular, enterprise-support programmes should help women- and youth-led CEEs move beyond low-margin activities towards higher-value segments of the clean-energy value chain.

Box 2. Business-model lessons from the EVI-SICEE enterprise case studies

The four case studies illustrate that women- and youth-led CEEs can create and capture value through different, and sometimes overlapping, business models. Amahlathi Eco-Tech demonstrates a technology development and commercialisation model, in which locally developed clean technologies form the enterprise's core value proposition. Kusini Water combines a social-enterprise and partnership-oriented model with community-level delivery: its water purification systems are supported through relationships with municipalities, private-sector organisations and corporate social investment initiatives, while trained local "water champions" participate in operating water kiosks. Kaeane Renewable Energy Developers illustrates a technology and service-based waste-to-energy model, centred on the design and installation of biodigester systems. His Grace Biogas Cooperative demonstrates a community/cooperative and circular-economy model, in which locally available organic waste provides an input for energy production while digestate can generate additional value for agriculture. These cases indicate that viable clean energy business models may combine several sources of value rather than rely exclusively on the sale of energy. Revenue and enterprise opportunities can arise from technology sales, installation and maintenance, institutional contracts, service provision, community distribution and the productive use of waste-derived outputs. The cases also show that business-model scalability depends on factors beyond the technology itself, including access to finance, entrepreneurial and technical capabilities, certification, reliable markets, partnerships and appropriate business-development support.

3.7. Opportunities for women-led and youth-led CEEs in South Africa

South Africa's transition toward renewable energy presents scaling opportunities for women and youth entrepreneurs to participate in and benefit from the growing clean energy economy. The renewable energy sector, supported by programs such as the Renewable Energy Independent Power Producer Procurement Programme, continues to open pathways for local business participation across value chains. Women and youth, often marginalized in traditional energy industries, are increasingly positioned to leverage these opportunities through entrepreneurship, innovation, and social enterprise models that align with South Africa's Just Energy Transition agenda.

• Economic and employment opportunities in solar energy

Solar energy remains one of the most promising sub-sectors for inclusive entrepreneurship and job creation in South Africa. Studies indicate that the solar photovoltaic and solar water heating industries provide substantial employment opportunities in both manufacturing and installation segments (Mukoro et al., 2022). Solar-powered productive-use applications (PUE) such as solar-powered irrigation, refrigeration, and water pumping enable youth and women entrepreneurs to diversify income sources in agriculture and small business operations.

- **Innovation and business opportunities in the biogas sector**

The biogas subsector presents another emerging frontier for inclusive entrepreneurship. Despite challenges related to infrastructure and financing, localized biogas production systems offer significant business potential in rural and peri-urban areas. According to Rasimphi et al. (2024), small-scale digesters that convert organic waste into energy can create new entrepreneurial ventures that generate both clean energy and organic fertilizer, thereby providing dual-income streams for households and cooperatives. For women, biogas entrepreneurship can reduce the burden of household energy management by replacing traditional biomass fuels, while also enabling participation in waste-to-energy enterprises. These initiatives align with national efforts to promote circular economy solutions, positioning biogas as a strategic sector for inclusive green entrepreneurship.

- **Local economic transformation and market creation**

The phasing out of coal presents major opportunities for local business diversification and the creation of new clean energy value chains. Research by Semelane et al. (2021) on the Steve Tshwete Local Municipality (STLM) highlights how transitioning coal-reliant economies toward solar PV and related technologies can catalyze local market development. Local SMEs many of which are youth- or women-led can play a critical role in solar value chain integration, including equipment assembly, maintenance services, and local distribution networks. Incentivizing businesses currently servicing the coal sector to pivot toward renewable energy could accelerate the diffusion of clean technologies and ensure that economic benefits remain within affected communities. This localized energy transition model can be replicated in other coal-dependent municipalities across South Africa, thereby broadening access to new business and employment opportunities while supporting equitable regional development.

- **Entrepreneurship, incubation, and capacity-building opportunities**

Entrepreneurial incubators and innovation hubs present vital platforms for fostering women and youth participation in the clean energy economy. According to Mgweba & Lungisa (2024) business incubation initiatives are instrumental in developing entrepreneurial competencies, offering mentorship, access to finance, and exposure to industry networks. However, local government constraints such as inadequate funding and limited coordination currently hinder the effective implementation of such incubators. Strengthening municipal collaboration with educational institutions, private investors, and development agencies could help establish targeted renewable energy entrepreneurship programs that prepare youth for participation in both employment and enterprise creation. Furthermore, as entrepreneurship serves as a key engine of economic development. By linking training programs, access to seed funding, and business mentorship to renewable energy initiatives, women and youth can be empowered to lead clean energy startups that drive sustainable growth and innovation.

South Africa's clean energy transition offers an expanding array of opportunities for women and youth-led enterprises across solar and biogas value chains. From local manufacturing and installation to waste-to-energy innovation and community energy distribution, the sector presents multiple entry points for inclusive entrepreneurship. Harnessing these opportunities, however, requires targeted interventions that strengthen policy coherence, financial inclusion, technical training, and market development support. By expanding access to entrepreneurship incubators, concessional finance, and gender-responsive capacity-building initiatives, South Africa can unlock the transformative potential of women and youth as key drivers of a just, inclusive, and sustainable energy future.

3.8. Policies & regulatory frameworks governing the clean energy ecosystem in South Africa

South Africa's energy policy landscape provides the overarching framework for guiding the transition toward a sustainable, inclusive, and low-carbon economy.

While the country has made significant progress in establishing legislative and strategic instruments to promote renewable energy such as the Integrated Resource Plan, the National Development Plan 2030, and the South African Renewable Energy Masterplan the extent to which these policies explicitly address gender equality and youth inclusion in clean energy entrepreneurship remains limited. Overall, the current policy ecosystem emphasizes energy security, economic growth, and decarbonization, with only fragmented references to social inclusion or empowerment of women and youth. This section summarizes the key policy provisions and identifies gaps (see Table 5) where gender- and youth-responsive mechanisms could be strengthened to ensure an equitable energy transition.

Table 5: Policies regulatory frameworks governing the clean energy ecosystem in South Africa

Policy	Description	Provisions/ gaps for support for women & youth in clean energy in South Africa in the following policies
National Energy Regulator Act (No. 40 of 2004)	Established the National Energy Regulator of South Africa (NERSA) to oversee electricity, piped gas, and petroleum pipelines under the Electricity Regulation Act (No. 4 of 2006), the Gas Act (No. 48 of 2001), and the Petroleum Pipelines Act (No. 60 of 2003). NERSA is also responsible for determining electricity tariffs.	Gap: The Act does not integrate equity-based regulatory mechanisms such as gender-responsive licensing frameworks or youth participation quotas in renewable energy projects. Regulatory reforms could promote inclusive ownership structures and broaden participation in energy markets.
National Energy Act (No. 34 of 2008)	The Act aims to ensure the availability of diverse, sustainable, and affordable energy resources, including renewables, to support South Africa's economic growth. It also provides for the establishment of institutions to promote energy efficiency.	Promotes universal energy access, which indirectly benefits women in energy-poor communities. Encourages development of renewable energy technologies and local capacity-building. Gap: The Act lacks explicit gender and youth mainstreaming provisions, such as inclusion targets, enterprise development programs, or gender-sensitive implementation frameworks.
Electricity Regulation Act (No. 4 of 2006)	The Act provides a national regulatory framework for the electricity supply industry, with NERSA as the enforcer. It governs licensing and registration processes for electricity generation, transmission, distribution, trading, and import/export activities.	Gap: Enables small-scale embedded generation (SSEG), creating potential entry points for youth- and women-led renewable energy SMEs. There are no targeted support mechanisms to ensure equitable participation of women and youth in IPP procurement, SSEG licensing, or tariff-setting processes.
Integrated Resource Plan (IRP)	The IRP 2023 highlights renewable energy as a priority, including the scaling of solar, wind, and biomass energy sources. This framework creates market opportunities for SMEs in energy generation, distribution, and related services. The primary purpose of the IRP is to ensure a reliable electricity supply by aligning generation capacity with demand while considering environmental considerations and the overall cost of energy production (Department of Energy, 2023).	Advocates for diversification of the energy mix and increased renewable capacity. Recognizes the importance of the Just Energy Transition (JET) in ensuring that workers and communities are not left behind. Gap: While the IRP acknowledges "just transition" principles, it does not operationalize them through gender- or youth-specific inclusion targets, capacity-building initiatives, or entrepreneurship support in clean energy value chains. The plan remains technocratically focused, with limited mechanisms for social equity integration.
National Development Plan (NDP) 2030	The NDP emphasizes sustainable and inclusive economic growth, prioritizing support for small businesses and increasing the participation of women and youth in the green economy.	Recognizes the role of energy in achieving inclusive growth and environmental sustainability. Emphasizes youth employment and women's empowerment as cross-cutting priorities in national development. Gap: Despite this recognition, the NDP does not translate these commitments into sector-specific interventions within the energy transition. There is a lack of clear linkages between gender/youth development goals and renewable energy implementation strategies.
South African Renewable Energy Masterplan (SAREM)	This strategy seeks to capitalize on the growing demand for renewable energy and storage technologies. It aims to drive industrial development and inclusive growth by fostering local value chains, including solar manufacturers, installers, and battery technologies like lithium-ion and vanadium.	Emphasizes local content, skills development, and job creation, aligning with the Just Energy Transition. Identifies opportunities for SMEs in renewable energy supply chains. Gap: Although SAREM recognizes the need for inclusivity, it does not explicitly define gender and youth inclusion mechanisms in value chain localization or enterprise development programs. This creates a policy-to-practice gap in ensuring equitable access to renewable energy markets.

Energy Action Plan	Developed during the national disaster on energy, this plan focuses on ending load-shedding and accelerating efforts to bring additional electricity supply to the grid.	Supports the scaling of distributed renewable energy and microgrids. Prioritizes job creation and local manufacturing. Gap: The plan is implementation-focused and does not explicitly integrate gender-responsive budgeting, youth entrepreneurship funding, or inclusive training programs.
White Paper on Energy Policy of the Republic of South Africa	The White Paper on Energy Policy is an overarching document which sets out the government's official policy on the supply and consumption of energy for the next decade. In a general sense it represents for the first time a comprehensive and holistic perspective of South Africa's official overall energy needs and options.	Stresses the need for universal access to affordable and sustainable energy. Encourages community energy projects and decentralization. Gap: Despite its social objectives, the policy does not mention gender or youth empowerment. It lacks the equity lens now considered central to a just and inclusive energy transition.
White Paper on the Renewable Energy Policy of the Republic of South Africa	The White Paper on Renewable Energy ("Renewable Energy White Paper") complements the White Paper on Energy Policy, by pledging "Government support for the development, demonstration and implementation of renewable energy sources for both small and large-scale applications	Introduces the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). Emphasizes capacity-building, R&D, and market development. Gap: Gender and youth dimensions are absent, and participation frameworks within REIPPPP remain limited to economic development scorecards, which include but do not prioritize gender or youth empowerment.
The Energy Efficiency Strategy	The Energy Efficiency Strategy aims to assist in providing energy for all residents of South Africa, by reducing energy consumption through efficient practices and sustainable energy development.	Encourages behavioral change and skills development for energy management. Supports industrial and commercial efficiency initiatives. Gap: The strategy lacks specific focus on women and youth-led energy efficiency enterprises or training programs that could create employment in auditing, retrofitting, and energy services.
Mineral and Petroleum Resources Development Act, 28 of 2002 (MPRDA)	The MPRDA is relevant here because it encapsulates not only "minerals", the primary sources of energy but also "petroleum", having a specific chapter dedicated to "Petroleum exploration and production".	Encourages Broad-Based Black Economic Empowerment (BBBEE) and local participation. Gap: While transformation is emphasized, gender- and youth-specific inclusion in renewable energy resource licensing and ownership remains weakly defined.

A review of South Africa's energy policy landscape reveals several cross-cutting findings that underscore both progress and persistent gaps in advancing gender and youth inclusion within the clean energy sector. Firstly, gender and youth mainstreaming remain limited across the policy framework. Although most policies acknowledge inclusive development and the need to expand participation in the energy economy, few translate these commitments into actionable strategies or measurable outcomes. There are no explicit inclusion targets, monitoring indicators, or dedicated funding mechanisms that ensure women and youth are equitably represented within clean energy enterprises, value chains, or decision-making spaces. As a result, gender and youth considerations often remain rhetorical rather than operational.

Secondly, the implementation of social inclusion measures is fragmented and uncoordinated. While individual policy documents such as the National Development Plan 2030 and the South African Renewable Energy Masterplan reference empowerment and job creation, these efforts occur in isolation and without a unified national framework that connects energy policy with entrepreneurship, education, and inclusion. This lack of institutional coherence weakens the overall impact of clean energy programs and limits opportunities for women and youth to access markets, financing, and training.

Finally, there is a strong need for enabling mechanisms that can bridge the gap between policy intent and practice. Effective inclusion requires the introduction of gender-responsive financing schemes, targeted capacity-building programs, and business incubation initiatives designed specifically for youth- and women-led clean energy enterprises. In addition, partnerships between government, private sector actors, and development agencies should focus on building local skills pipelines, providing mentorship, and expanding access to credit and market linkages.

By embedding these enabling structures, South Africa can move from policy statements to tangible outcomes that empower women and youth as active agents in the country's just and sustainable energy transition.

3.9. Clean energy hubs and support platforms in South Africa

South Africa's clean-energy entrepreneurship ecosystem includes business incubators, research and technology organisations, sector-development agencies, skills institutions and university-based innovation platforms. These organisations can support SMEs through business incubation, technical assistance, skills development, technology testing and validation, market intelligence, networking and connections to finance and markets. Such intermediary organisations are particularly important in green innovation ecosystems because emerging enterprises often lack the internal technical, financial and commercial capabilities required to move from an innovative idea to a market-ready business (Soares et al., 2026).

Importantly, most clean-energy hubs and support platforms in South Africa are not exclusively targeted at women- and youth-led enterprises. They generally support SMEs, innovators or clean energy entrepreneurs, among which women and young entrepreneurs may be beneficiaries. Some programmes have stronger youth, transformation or inclusion objectives, but publicly available information does not consistently report beneficiaries simultaneously by gender, age, technology and enterprise type. It is therefore difficult to quantify how many women- and youth-led solar or biogas SMEs have been supported through these platforms (see Table 6 for more details). This represents an important evidence gap.

1. South African Renewable Energy Business Incubator

The South African Renewable Energy Business Incubator (SAREBI) is one of the specialised enterprise-support initiatives associated with renewable energy and clean technologies in South Africa. It has operated with support from the Small Enterprise Development Agency (SEDA) and provides incubation and business-development support to enterprises participating in renewable-energy and energy-efficiency markets. SAREBI is relevant to women- and youth-led CEEs because specialised incubation can help emerging enterprises strengthen their business models, develop commercialisation strategies, build managerial capabilities and connect with potential partners and markets. However, SAREBI should not be described as exclusively serving women and youth unless programme-specific evidence demonstrates this. Publicly available information does not provide a sufficiently robust current figure for the number or percentage of SAREBI-supported businesses that are simultaneously women-led, youth-led and operating specifically in solar or biogas. This distinction is consistent with broader African evidence. Ailyn (2024) identify incubators and accelerators as important components of green-innovation ecosystems because they can provide entrepreneurs with business-development services, networks and connections to finance. Similarly, Chematia, (2025), examining women- and youth-led CEEs in Kenya, finds that incubation can strengthen firm capabilities but that access, quality and continuity of incubation support are critical to enterprise growth.

2. Energy and Water Sector Education and Training Authority

The Energy and Water Sector Education and Training Authority (EWSETA) contributes to South Africa's energy-transition ecosystem primarily through skills development rather than direct clean-energy business incubation. Its mandate covers skills development in the energy and water sectors and involves collaboration with employers, education and training institutions and other stakeholders. EWSETA's relevance to women and young people lies particularly in building the technical and occupational skills pipeline needed for participation in emerging energy industries. Training, workplace learning and occupational development can provide pathways through which young people acquire capabilities that can subsequently support employment, self-employment or enterprise development.

3. EnergyDRIVE and youth clean-energy awareness

The EnergyDRIVE initiative, associated with the South African Wind Energy Association (SAWEA), and partner organisations, represents a different form of ecosystem intervention. Rather than incubating existing SMEs, the mobile educational initiative exposes school learners and communities to renewable-energy technologies, climate change, energy efficiency and potential opportunities within the green economy. EnergyDRIVE is therefore relevant primarily as a youth awareness and future skills-pipeline initiative, rather than a financing or enterprise-incubation platform. Its value lies in exposing young people, particularly those living near renewable-energy developments, to clean-energy technologies and potential career pathways.

4. South African National Energy Development Institute

The South African National Energy Development Institute (SANEDI) forms part of South Africa's national energy research, development and innovation infrastructure. Its work covers areas including renewable energy, energy efficiency, cleaner mobility and related energy technologies. SANEDI's contribution to enterprise development is therefore primarily through knowledge generation, research, technology demonstration and innovation support, rather than conventional SME incubation. For women- and youth-led CEEs, access to research and demonstration infrastructure can be valuable because small technology enterprises often lack the resources required to independently undertake research, technology testing and demonstration. Organisations such as SANEDI can therefore form part of the broader knowledge infrastructure surrounding enterprise innovation. However, publicly available evidence does not support presenting SANEDI as an organisation specifically or exclusively targeting women- and youth-led CEEs.

5. GreenCape and green-economy market development

GreenCape is a South African non-profit green-economy organisation that works with businesses, investors, government and other stakeholders to support green-economy investment and market development. One of its important contributions is the production of Market Intelligence Reports [2], which provide information on market conditions, investment opportunities, regulatory developments and emerging opportunities in sectors including energy services, renewable energy, sustainable agriculture, water and the circular economy. For women- and youth-led CEEs, this type of support is important because access to reliable market information can help entrepreneurs identify customers, understand regulatory changes and assess commercial opportunities. GreenCape's industry networks and investment-facilitation activities can also potentially connect emerging entrepreneurs with larger ecosystem actors.

6. Gauteng Climate Innovation Centre/Climate Innovation Centre South Africa

The Climate Innovation Centre South Africa (CICSA) provides one of the strongest documented examples of specialised clean-technology incubation in South Africa. Gonsalves & Rogerson (2019) conducted a detailed study of the centre and report that it was launched in 2012 as part of the international Climate Innovation Centre model. Importantly, their peer-reviewed study reports that 62 clean-technology enterprises had been supported during CICSA's first five years of operation. However, available evidence does not provide sufficient gender- and age-disaggregated information to determine how many of these enterprises were women- or youth-led.

7. University and research-based technology hubs

Universities and public research organisations provide another important layer of support. The University of Johannesburg's Process, Energy and Environmental Technology Station (UJ PEETS) provides technology-related support connecting academic expertise with industry and SMEs. Such university-based technology stations can provide access to specialised knowledge, researchers, technology-development capabilities and facilities that smaller enterprises may not possess internally.

[2] <https://greencape.co.za/market-intelligence/>

Similarly, research and capacity-development activities associated with the University of Venda are relevant to the development of biogas knowledge and capabilities in Limpopo. University engagement can be particularly valuable for emerging biogas enterprises because technology adoption depends on technical knowledge, appropriate biodigester design and construction, maintenance skills and community awareness. The role of universities is therefore broader than conventional entrepreneurship education. They can operate as innovation intermediaries, connecting women- and youth-led enterprises with research, technical expertise, technology validation, students, laboratories, mentors and industry partners. Recent South African research Gumbo & van der Westhuizen (2026) similarly highlights the potential for universities to operate as coordinators and enablers within entrepreneurship ecosystems.

Table 6: Hubs and support platforms in South Africa. Source ; SAWEA(2023))

Platform	Verified/reasonably supportable figure	What the figure does not show
CICSA	62 clean-tech enterprises supported during its first five years	Does not establish how many were women- or youth-led
SAREBI	No current gender/age-disaggregated figure verified	Cannot claim a specific number of women/youth CEEs supported
EWSETA	Programme and skills data exist, but no clean-energy CEE gender/age figure verified here	Training beneficiaries cannot automatically be classified as entrepreneurs
SANEDI	Multiple R&D/demonstration programmes	No verified national count of women/youth CEEs supported
GreenCape	Extensive green-economy market-development activities	No verified figure identified for women/youth-led solar/biogas SME beneficiaries
UJ PEETS	Technology/SME-support mandate	No verified women/youth clean-energy SME beneficiary count identified

The available evidence therefore indicates that South Africa has multiple clean-energy and green-economy support institutions, but limited publicly available data showing how effectively these platforms reach women- and youth-led CEEs. Most platforms are not exclusively targeted at women and youth, and programme statistics are rarely disaggregated simultaneously by gender, age, enterprise ownership and clean-energy technology. This is itself an important finding for the scoping study. Without gender- and age-disaggregated monitoring, it is difficult to determine whether clean-energy incubation, skills, research infrastructure and market-support programmes are contributing equitably to enterprise development. Support organisations should therefore monitor not only the total number of entrepreneurs or enterprises assisted, but also women- and youth-led enterprise participation, technology subsector, location, type of support received, and progression from incubation to commercialisation and scaling.

3.10. Gaps identified

The scoping study reveals a growing clean energy entrepreneurship ecosystem in South Africa, but also identifies important evidence, policy, financing, institutional and market gaps that limit understanding of and support for women- and youth-led CEEs.

- **Limited gender- and age-disaggregated enterprise data.** One of the most significant gaps is the absence of a comprehensive national database of women- and youth-led CEEs. Available SME and clean-energy datasets rarely disaggregate enterprises simultaneously by gender, age, technology, province, enterprise size and stage of development.

- Consequently, it is difficult to establish how many women- and youth-led enterprises operate in solar, biogas and clean cooking; where they are located; how many survive beyond start-up; and how many progress to commercial scale. The same problem is evident in support programmes: although South Africa has several clean-energy and green-economy support institutions, publicly available programme data do not consistently show how many beneficiaries are women- or youth-led CEEs. Improved disaggregated monitoring is therefore necessary for assessing whether the benefits of the clean energy transition are being distributed inclusively.
- **Limited South Africa-specific research on women- and youth-led CEEs.** Although substantial literature exists on clean energy, SMEs and entrepreneurship separately, relatively little empirical research examines the intersection of clean energy entrepreneurship, gender, youth and enterprise scaling in South Africa. This is particularly evident in the biogas subsector and in research examining how women- and youth-led enterprises progress from start-up to commercialisation and scaling. The review therefore had to draw selectively on wider African evidence where South Africa-specific evidence was unavailable. This limits the ability to determine whether findings from other contexts apply directly to South African CEEs.
- **A financing gap between start-up and commercial scale.** South Africa has financing mechanisms for SMEs and targeted mechanisms for women and young entrepreneurs, including grants and development-finance instruments. However, the review indicates a continuing mismatch between the financing needs of CEEs and conventional financing requirements. Clean-energy businesses may require finance at multiple stages for technology development, demonstration, testing and certification, equipment, working capital, production and market expansion, while conventional finance often depends on collateral, established credit histories, financial records and demonstrated turnover. These conditions can be particularly difficult for young entrepreneurs with short business and credit histories and for women entrepreneurs facing wider structural inequalities in access to finance (Machingambi & Rankhumise, 2026). Kingiri et al. (2025) also highlights the need for financing models designed around the different stages of development of women- and youth-led CEEs.
- **Fragmentation of enterprise-support mechanisms.** South Africa has incubators, universities, research organisations, development-finance institutions, skills agencies and market-development platforms, but these resources do not necessarily form a coherent pathway for enterprise scaling. An entrepreneur may need to obtain technical assistance from one institution, business incubation from another, testing and certification elsewhere, and finance and market access through separate institutions. This fragmentation can be particularly difficult for newer enterprises with limited institutional networks. The gap is therefore not simply the availability of support, but coordination between technology development, incubation, certification, finance, procurement and markets.
- **Limited evidence on the effectiveness of incubation and support programmes.** Existing programmes commonly report activities such as enterprises supported, participants trained or programmes delivered, but there is less systematic evidence on longer-term enterprise outcomes. In particular, more evidence is required on whether women- and youth-led CEEs receiving incubation or technical assistance subsequently secure finance, obtain certification, enter procurement systems, increase revenues, create employment or achieve commercial scale. The scoping study finds that programme statistics are rarely sufficiently disaggregated to assess these outcomes specifically for women and youth.
- **Policy inclusion does not necessarily translate into implementation.** South Africa's energy, SME-development and just-transition frameworks create opportunities for inclusive participation, but a gap remains between broad commitments to transformation and the practical conditions experienced by emerging enterprises. Women and young entrepreneurs must still navigate finance, certification, procurement, skills and market-access barriers. Inclusive policy therefore needs to move beyond recognising women and youth as priority groups towards measurable mechanisms that improve their access to finance, procurement, technical infrastructure, business networks and emerging clean-energy value chains.

- **Unequal access to networks and markets.** The review shows that women- and youth-led CEEs can experience the same market and institutional constraints as other SMEs but may have fewer resources with which to navigate them. Young entrepreneurs have had less time to accumulate business experience, assets and professional networks, while women may additionally encounter gendered barriers relating to technical credibility and participation in male-dominated business networks. Pettersen et al., (2025) similarly demonstrates the importance of networks and intersectionality in shaping Black women's entrepreneurial opportunities.
- **Limited evidence on viable and scalable business models.** The scoping study identifies several potential clean-energy business models, including direct product sales, installation and maintenance, energy-as-a-service, PAYG and lease-to-own arrangements, institutional contracting, cooperatives and community-based enterprises. However, there is limited longitudinal South African evidence comparing which models are most financially sustainable and scalable for women and young entrepreneurs. Further research is particularly needed on revenue models, profitability, financing requirements, customer acquisition and movement into higher-value segments of solar and biogas value chains.

Taken together, these gaps point to a broader evidence-to-implementation gap. South Africa has policies, financing institutions, support organisations, research capabilities and growing clean-energy markets, but these elements are not yet sufficiently connected or monitored from an inclusion perspective. Future research should therefore move beyond documenting participation towards examining who enters clean-energy value chains, what support they receive, whether they can access finance and markets, and what enables women- and youth-led enterprises to progress from start-up to sustainable commercial scale.

4. Conclusion

South Africa's transition towards a cleaner and more diversified energy system creates important opportunities for enterprise development, innovation, employment creation and inclusive economic participation. This scoping study identifies multiple entry points for women and young entrepreneurs across clean energy value chains, particularly in solar and biogas, including technology development, installation and maintenance, distribution, energy services, community-based enterprises and waste-to-energy activities. However, the study should not be interpreted as a quantitative census of women- and youth-led CEEs in South Africa. Rather, its principal contribution is to provide an analytical and diagnostic framework for understanding the conditions that shape inclusive clean energy entrepreneurship and for informing subsequent policy, programme and research design.

This distinction is important because the available evidence does not permit reliable estimates of the size, geographic distribution, technology focus, performance or scaling trajectories of the women- and youth-led CEE population. National datasets do not sufficiently disaggregate enterprises simultaneously by sector, gender, age, enterprise size and location, while programme-level monitoring data are similarly fragmented. Consequently, the study draws on a combination of clean-energy-specific literature, broader South African SME and entrepreneurship research, policy and institutional documents, and qualitative enterprise case studies. The case studies provide illustrative evidence of entrepreneurial pathways and experiences rather than a statistically representative picture of the sector. Similarly, findings drawn from the broader SME literature provide important contextual evidence on constraints likely to affect clean energy entrepreneurs but should not be interpreted as direct quantitative evidence on the CEE population.

Within these evidence limitations, the study identifies a consistent set of systemic factors that warrant attention in policy and programme design.

Access to appropriate finance, technical and entrepreneurial capabilities, technology testing and certification, market development, procurement opportunities, business networks and institutional support all influence the capacity of enterprises to enter and progress through clean energy value chains. Women and young entrepreneurs operate within the wider constraints affecting South African SMEs, but their capacity to navigate these constraints may differ because of disparities in accumulated assets, business track records, professional networks and access to technical and commercial opportunities. The findings therefore point to the importance of examining not only whether clean energy opportunities exist, but also who can access them, under what conditions, and with what enterprise outcomes.

The diagnostic analysis also identifies a substantial but fragmented support ecosystem. Incubators, universities and research organisations, skills-development institutions, development-finance organisations, government agencies and industry platforms can provide technical knowledge, technology validation, business development, finance, skills, networks and market connections. The policy challenge is therefore not simply to increase the number of support initiatives, but to improve coordination and ensure that appropriate forms of support are available at different stages of enterprise development. The study consequently proposes an enterprise-scaling pathway connecting skills and innovation, technology development and validation, incubation, testing and certification, appropriate finance, demonstration and procurement, market entry and commercial scaling. Financing mechanisms should similarly respond to different stages of the enterprise lifecycle rather than treating enterprise finance as a single intervention.

Viewed in this way, the study provides a framework that policymakers and enterprise-support organisations can use to diagnose where constraints occur along the enterprise development pathway and where interventions may be required. It highlights the need to consider the interaction between finance, skills, technology, regulation, markets, networks and institutional support rather than addressing these barriers independently. This systems perspective is particularly relevant for women- and youth-led CEEs because enterprise outcomes are shaped not only by individual entrepreneurial capabilities but also by the wider innovation and business environment within which entrepreneurs operate. The report's conceptual framework similarly positions policy, business models and enabling conditions as interconnected dimensions of inclusive clean energy entrepreneurship.

A central implication of the scoping study is therefore the need to strengthen the evidence infrastructure underpinning clean energy enterprise policy. Future research and monitoring should generate consistent gender- and age-disaggregated data on enterprise ownership and leadership, technology focus, geographic location, financing, participation in support programmes, market access, survival, growth and progression to commercial scale. Longitudinal evidence is particularly important for determining which financing mechanisms, business models and incubation interventions produce sustained enterprise outcomes. The evidence gaps identified by this study should therefore inform subsequent empirical phases of the EVI-SICEE project rather than be interpreted simply as limitations of the review.

Overall, the study's contribution lies less in quantifying the population of women- and youth-led CEEs than in mapping the emerging ecosystem, identifying critical evidence gaps, diagnosing systemic constraints and opportunities, and providing an analytical basis for more targeted policy and programme interventions. Scaling women- and youth-led CEEs should therefore be approached as an innovation-system and enterprise-development challenge requiring coordinated action across government, finance, research and technology organisations, incubators, industry, municipalities and communities. Progress should ultimately be assessed through improved evidence on whether women and young entrepreneurs can access resources and higher-value opportunities, develop sustainable enterprises, progress towards commercial scale and participate meaningfully in the economic benefits generated by South Africa's clean energy transition.

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6. APPENDICES

Appendix 1: List of literature analyzed for the scoping study

Type	Author (Year)	Title
Journal article	Adebiyi, A. A., & Moloi, K. (2024)	Renewable Energy Source Utilization Progress in South Africa: A Review
Website	AEP. (2018)	AfDB Grants South Africa \$474.6m Loan to Boost Energy
Journal article	Akinbami, O. M., Oke, S. R., & Bodunrin, M. O. (2021)	The state of renewable energy development in South Africa: An overview
Journal article	Chidembo, R., Francis, J., & Kativhu, S. (2024)	Underlying beliefs that influence solar home system adoption in Vhembe district Municipality, South Africa
Report	CONVERGENCE. (2024)	State of Blended Finance 2024- Climate Edition
Journal article	Dlamini, S. (2023)	The role of the institutional environment as a barrier or an enabler to entrepreneurial and innovation activity; the case of the South African green economy industry
Report	DMRE. (2023)	Integrated Resource Plan (IRP) -2023
Report	DNT. (2021)	Financing a Sustainable Economy
Journal article	Ettmayr, C., & Lloyd, H. (2017)	Local content requirements and the impact on the South African renewable energy sector: A survey-based analysis
Report	EWSETA. (2021)	Water sustainability sector skills plan energy
Website	Ferris, N. (2023)	South Africa's unprecedented rooftop solar boom
Report	Green Cape. (2024)	Large-scale-RE-MIR-2024-digital.pdf
Report	Green Cape. (2025a)	Atlantis-Short-version
Report	Green Cape. (2025b)	Renewable energy: Market intelligence report 2025
Report	Green Finance Platform. (2022)	Assessment of Green Financing Mechanisms for MSMEs in Africa (1)
Website	Green Youth. (2025)	Green Youth Network's Prelude to the Green Youth Indaba – Green Youth Indaba
Report	GSG Impact. (2023)	Uct-iisa-2023-biennial-report
Journal article	Heuër, A. (2017)	Women-to-women entrepreneurial energy networks: A pathway to green energy uptake at the base of pyramid
Report	IRENA. (2022)	Renewable Energy Market Analysis: Africa and its Regions
Report	IRENA. (2025)	IRENA_SOC_Renewable_energy_gender_perspective_2Ed_2025
Journal article	Irene, B. et al. (2025)	The Role of Financial Institutions in Bridging the Financing Gap for Women Entrepreneurs in Sub-Saharan Africa

Journal article	Kamusoko, R., & Mukumba, P. (2025a)	Valorization of Maize Stover into Biogas for Heat and Power Generation: A South African Perspective
Journal article	Khodayar, M. E., Feizi, M. R., & Vafamehr, A. (2019)	Solar photovoltaic generation: Benefits and operation challenges in distribution networks
Website	Kruger, S. (2024)	Jobs of the future: South Africa has major gaps in skills needed to shape the green economy
Journal article	Matlhake, L., & Kalitanyi, V. (2025a)	Assessing the Barriers Faced by Youth-Owned Micro, Small and Medium Enterprises in Johannesburg
Journal article	Mgweba, L., & Lungisa, S. (2024)	Impact of entrepreneurial incubators on youth employment in South African local government
Website	Moyo, A. (2023)	New portal displays SA's solar installation data
Website	Mubika, R. (2025)	Sandiswa Qayi: From Rural Roots to Clean Tech Trailblazer
Journal article	Mkhwebanel & Ntulili (2019)	Alternatives for small, medium and micro scale enterprises participation in the renewable energy industry - small scale embedded generation review
Thesis	Nwabisa (2024)	An Exploratory Study of Financial Access Along the Renewable Energy Sector Value Chain: The Case of SMEs in South Africa
Journal article	Verlinda Attipoe et al. (2023)	Designing a Data-Driven Sustainable Finance Model: A Pathway for Small and Medium Enterprises to Transition to Clean Energy
Report	Pitlo, Ivy Vivian (2025)	Funding Models for Small Medium and Micro Enterprises (SMEs)' Survival in the West Rand District Municipality
Report	Olawale Fatoki (2014)	The Financing Options for New Small and Medium Enterprises in South Africa
Journal article	Msomi, T. S. & Olarewaju, O. M. (2021)	Factors Affecting Small and Medium Enterprises' Financial Sustainability in South Africa
Report	Sizwe Ntumba (2022)	The scaling up of renewable energy consumption in South Africa; challenges and opportunities
Report	Shellfoundation (2025)	Assessment of Women Livelihoods within the Climate-Smart sector
Report	Cleantech hub (2025)	Addressing Barriers to Women Entrepreneurs in Clean Energy
Report	UN Women (2023)	Gender equality in the sustainable energy transition
Journal article	Diale, C. D., Kanakana-Katumba, M. G., & Maladzi, R. W. (2021)	Ecosystem of Renewable Energy Enterprises for Sustainable Development: A Systematic Review
Report	Francois Viljoen (2014)	A sustainable strategic architecture for the provision of solar energy to SMEs In Africa
Report	Silvia Emili et al. (2016)	Supporting SMEs in designing sustainable business models for energy access for the BoP: a strategic design tool
Journal article	Pizzi, S., Corbo, L., & Caputo, A. (2020)	Fintech and SMEs sustainable business models: reflections and considerations for a circular economy

Report	Whitney Lisa Pailman (2016)	An Explorative Study of the Synergy between Social Enterprises and Local Micro-entrepreneurs in the Provision of Off-grid Clean Energy Access
Journal article	Adenle (2018)	Assessment of solar energy technologies in Africa- opportunities and challenges in meeting the 2030 agenda and sustainable development goals
Journal article	Ndembele et al. (2022)	The Challenges of Youth Entrepreneurship from a Local Government Perspective in South Africa
Journal article	Rasimphi et al. (2024)	Challenges, Opportunities, and possible Interventions in the Biogas sector in Rural areas of Limpopo, South Africa
Journal article	Stanley Semelane et al. (2021)	Evaluating available solar photovoltaic business opportunities in coal phase-out regions – An energy transition case of Steve Tshwete local municipality in South Africa
Report	4IP Group (2025)	Financing Approaches to The Energy Transition in South Africa
Website	SAREBI (2025)	Turning entrepreneurs into better business people

Appendix 2: Systemic barriers

Author (Year)	Title	Systemic barriers
Mkhwebanel & Ntulili (2019)	Alternatives for small, medium and micro scale enterprises participation in the renewable energy industry - small scale embedded generation review	Lack of regulatory framework, high capital requirements, poor-quality installations, lack of local manufacturing, and absence of technical standards hamper SME participation.
Nwabisa (2024)	An Exploratory Study of Financial Access Along the Renewable Energy Sector Value Chain: The Case of SMEs in South Africa	Stringent lending criteria and high collateral requirements limit financial access for SMEs; alternative financing options remain underutilized.
Verlinda Attipoe et al. (2023)	Designing a Data-Driven Sustainable Finance Model: A Pathway for Small and Medium Enterprises to Transition to Clean Energy	Exclusion from traditional finance due to perceived risk; systemic financial, regulatory, and technological barriers persist.
Pitlo, Ivy Vivian (2025)	Funding Models for Small Medium and Micro Enterprises (SMEs), Æ Survival in the West Rand District Municipality	Mismatch between funding models and SME needs in rural areas; financial illiteracy and limited funding access hinder growth.
Olawale Fatoki (2014)	The Financing Options for New Small and Medium Enterprises in South Africa	Access to finance remains a primary barrier to SME survival and growth.
Msomi, T. S. & Olarewaju, O. M. (2021)	Factors Affecting Small and Medium Enterprises, Æ Financial Sustainability in South Africa	Low financial literacy and risk misjudgment limit SMEs' ability to pursue high-return opportunities.
Sizwe Ntumba (2022)	The scaling up of renewable energy consumption in South Africa; challenges and opportunities	Skills shortages, inadequate investment models, incoherent policies, and lack of actor engagement impede RE scale-up.
Shellfoundation (2025)	Assessment of Women Livelihoods within the Climate-Smart sector	Women face systemic exclusion via limited funding, poor market access, minimal training, and cultural/logistical barriers.

Cleantech hub (2025)	Addressing Barriers to Women Entrepreneurs in Clean Energy	Women face barriers including finance access, gender bias, limited mentorship, inadequate policies, and skills gap in clean energy.
Matlhake & Kalitanyi (2025)	Assessing the Barriers Faced by Youth-Owned Micro, Small and Medium Enterprises in Johannesburg	Funding constraints, bureaucratic inefficiencies, low entrepreneurial education, and regulatory burdens hinder youth business growth.
UN Women (2023)	Gender equality in the sustainable energy transition	Public procurement challenges, gender finance gap, burdensome compliance, and unequal power dynamics disadvantage women-led businesses.
Mgweba & Lungisa (2024)	Impact of entrepreneurial incubators on youth employment in South African local government	Lack of funding, change management, and innovation hinder local government support for youth-focused incubators and employment.

Appendix 3: Business models

Author & year	Title	Business Models Summary
Diale et al, (2021)	Ecosystem of Renewable Energy Enterprises for Sustainable Development: A Systematic Review	Explores how different business structures (Pty Ltd, private companies, etc.) can benefit from renewable energy. Proposes mapping business model success factors to tailor funding/support. Introduces utility vs. customer energy models to support the RE value chain internationally.
Viljoen (2014)	A SUSTAINABLE STRATEGIC ARCHITECTURE FOR THE PROVISION OF SOLAR ENERGY TO SMES IN AFRICA	Defines business models as strategic tools for value creation. Emphasizes innovation and sustainability. Highlights emerging models like community-owned, leasing, and varied financing mechanisms from subsidies to private funding.
Emili et al, (2016)	Supporting SMEs in designing sustainable business models for energy access for the BoP: a strategic design tool	Advocates for Distributed Renewable Energy (DRE) systems and Product-Service Systems (PSS) as sustainable business models. Focuses on shifting from product sales to bundled services for underserved markets.
Pizzi et al, (2020)	Fintech and SMEs sustainable business models: reflections and considerations for a circular economy	Discusses Sustainable Business Models (SBMs) and Circular Economy Business Models (CEBMs). Emphasizes adapting or redesigning models to integrate social, ecological, and technological innovations with economic goals.
Pailman (2016)	An Explorative Study of the Synergy between Social Enterprises and Local Micro-entrepreneurs in the Provision of Off-grid Clean Energy Access	Explores social enterprise-led micro-franchising models involving local entrepreneurs. Benefits include income and training; challenges include attrition and scalability in nascent markets.
Heu'r (2017)	Women-to-women entrepreneurial energy networks: A pathway to green energy uptake at the base of pyramid	Presents a micro-consignment model allowing women entrepreneurs to start with low risk and scale up. Emphasizes ongoing support and reinvestment of profits for sustained income in clean energy sales.
Dlamini (2023)	The role of the institutional environment as a barrier or an enabler to entrepreneurial and innovation activity; the case of the South African green economy industry	Highlights adaptive business models in response to institutional barriers. Example: informal waste pickers integrated with fair wages. Entrepreneurs pivot models rather than exiting due to market and institutional pressures.

Appendix 4: Opportunities

Author (Year)	Title	Opportunities
Adebiyi & Moloi (2024)	Renewable Energy Source Utilization Progress in South Africa: A Review	SPV systems support job creation (direct, indirect, influenced) across manufacturing and installation. Promotes local economic growth, reduces fossil fuel reliance, and supports green jobs.
Adenle (2018)	Assessment of solar energy technologies in Africa- opportunities and challenges in meeting the 2030 agenda and sustainable development goals	SWH market expansion created jobs; suppliers increased. Industry expected to grow 40% and increase employment opportunities.
Ndembele et al. (2022)	The Challenges of Youth Entrepreneurship from a Local Government Perspective in South Africa	Local governments should improve communication to raise youth awareness of entrepreneurial development opportunities.
Rasimphi et al. (2024)	Challenges, Opportunities, and possible Interventions in the Biogas sector in Rural areas of Limpopo, South Africa	Biogas offers innovation and entrepreneurship opportunities, especially in waste-to-energy ventures that can generate income and offset startup costs in rural areas.
Stanley Semelane et al. (2021)	Evaluating available solar photovoltaic business opportunities in coal phase-out regions ,Āi An energy transition case of Steve Tshwete local municipality in South Africa	STLM's solar PV transition can spur local market creation, tech adoption, and service shifts from coal to clean energy. Incentives and innovation are critical to business integration.
Mgweba & Lungisa (2024)	Impact of entrepreneurial incubators on youth employment in South African local government	Incubators enhance youth entrepreneurship through training, skill development, and motivation. Entrepreneurship seen as a catalyst for long-term economic growth.
4IP Group (2025)	Financing Approaches to The Energy Transition in South Africa	SA has strong potential due to top-tier renewable resources, falling technology costs, and high investor interest in clean energy.

Evidence for informing optimization and scaling of youth and women-led clean energy enterprises and business models in Kenya, Malawi, Uganda & South Africa

Amahlathi Eco-Tech (AET)
CASE STUDY REPORT

University of Johannesburg, South Africa



Canada

Background

In South Africa, water heating accounts for a substantial portion of household electricity use, with geysers contributing between 25% and 40% of total electricity bills. In an effort to lower these costs, many households adopt manual practices such as switching geysers on only when hot water is needed and off immediately after. This practical challenge inspired Sandiswa Qayi to innovate the HotSpot device - a retrofit solution designed for both high-pressure electric and solar geysers (see Fig.A5.1). The HotSpot allows users to heat only the volume of water required (e.g., 50 litres instead of the full 150 litres), thereby reducing electricity consumption and enabling flexible control. Users can either continue switching their geyser on and off or leave it on, knowing the device will ensure energy-efficient heating. This significantly reduces energy waste and enhances monthly cost savings. The success of the HotSpot innovation has garnered wide recognition. It won the Youth-led Business Award and received accolades such as the Enviropaedia Eco-Logic Award for Energy Efficiency and the Department of Energy's Young Woman in Energy Award in 2017. These achievements elevated the profile of both the device and the parent company, Amahlathi Eco-Tech (AET) Africa, positioning it on the global stage.



Figure A5.1: Sandiswa Qayi, co-founder, AET-Africa, holding the HotSpot device. Source (Vukuzenzele, 2017).

Through programs led by the Department of Science and Technology's Technology Localisation Implementation Unit (TLIU) and the Grassroots Innovation Programme, AET Africa was selected to represent South African grassroots innovators at the Festival for Innovation and Entrepreneurship in India. The company has also been chosen among South Africa's Top 10 Venture Leaders for a business mission to Switzerland, signaling its readiness for international market expansion (Malema, 2018).

Amahlathi Eco-Tech (AET) operates in the clean tech space, focusing on energy efficiency—particularly targeting water heating for residential and small commercial markets. The company was started in 2012 with innovations like the Hotspot (a retrofit sleeve for water heaters to reduce electricity consumption) and the Heat Radar (a device that harvests waste heat from cooling systems and redirects it to water heating reducing electricity costs in residential and small commercial water heating systems).

This case study explores AET's journey, systemic challenges, funding mechanisms, market access issues, and strategic pivots, contributing insights to the broader EVI-SICEE objective of optimizing youth- and women-led clean energy enterprises across Africa.

Sandiswa Qayi's story

Raised between the rural villages of the Eastern Cape and the urban spaces of South Africa, Sandiswa Qayi's life has been one of contrast, adaptability, and purpose. Currently based in East London, she stands out as a pioneering figure in Africa's clean technology and energy advocacy space. As the founder of AET Africa, her transition from a background in industrial sociology to clean energy entrepreneurship reflects her drive to confront real-world issues—particularly those tied to energy poverty, affordability, and equitable access to hot water in underserved communities.

Her formative years were shaped by movement across different environments—from living with her grandparents in the countryside to navigating city life from the age of 11. This duality forged a flexible and visionary mindset, which has been instrumental in her journey through life and business. Though initially drawn to engineering due to her aptitude in maths and science, changes in her academic trajectory led her to pursue industrial sociology and organisational psychology at Rhodes University, later earning a Master's degree in development studies. These experiences equipped her with a systems-thinking lens that would deeply inform her entrepreneurial approach (Mubika, 2025).

Sandiswa's professional journey began in economic development, where she observed firsthand the energy challenges facing everyday South Africans—such as the need to manually manage geysers to save on electricity bills. Inspired by these realities and informed by discussions with peers in industrial parks, she co-founded AET Africa in 2012 to design and deliver affordable, energy-efficient technologies for local communities. AET's early years focused on research and prototyping, culminating in the launch of their flagship innovation—the Hotspot geyser sleeve, a retrofit solution that helps reduce electricity usage by heating only the required amount of water. This innovation directly addresses the high energy costs of water heating, which can constitute up to 40% of a household's electricity bill in South Africa. By 2015, Sandiswa took on the role of full-time Managing Director, steering the company towards scalable impact by blending local manufacturing with sustainable design. Her work through AET Africa represents a practical and transformative approach to energy access—bridging development goals with technological innovation grounded in lived experience.

Motivation

The motivation behind the founding of AET Africa was deeply rooted in both environmental and economic concerns. As co-founder Sandiswa Qayi observed the escalating costs of electricity and the pressing need to address climate change, she and her partners began to explore energy-efficient solutions tailored to local realities.

Sandiswa Qayi, CEO AET explained that "...the idea behind the company was really looking into how we contribute to the climate change issues. But at the same time, what was the main driver for us was to reduce the energy or electricity cost. Because at that stage, myself and my partners, we were working in an industrial park...when you are like a group of executives in an industrial park and you meet and discuss challenges. So, that's how the very first idea of us forming AET Africa came about. We played with several ideas until we really zoomed in and decided to drive the two innovations.

Initially working in an industrial park, they identified water heating as a significant contributor to electricity bills and saw an opportunity to innovate through retrofit technologies. Their vision was to reduce electricity consumption in residential and small commercial settings, while also contributing to environmental sustainability. The business was co-founded by Sandiswa Qayi and officially launched in 2012.

Support received (financial/ business support)

Initial R&D was supported by grants from Science & Technology Park, TIA, and SEDA. AET later attracted venture capital from IDC and support from CSIR. Participation in the Global Cleantech Innovation Program was pivotal, earning AET PR exposure and critical funding to scale operations. AET Africa's journey from concept development to commercialization was significantly shaped by a series of strategic funding interventions from both public and private institutions. In its early stages, the company benefited from government-assisted support, particularly through innovation-focused programs aimed at nurturing locally developed technologies. The initial funding was used to prototype and test early concepts like the Heat Radar and later the Hotspot device, which are both energy efficiency innovations aimed at reducing electricity costs in residential and small commercial settings.

One of the earliest breakthroughs came through a call for proposals issued by a Science and Technology Park, which enabled AET Africa to conduct its first proof-of-concept trials. This was followed by successful grant applications to the Innovation Hub in Pretoria and the Technology Innovation Agency (TIA), which provided critical resources for advanced prototype development and validation of the Hotspot product. In 2016, the company's trajectory was further accelerated when it joined the Global Cleantech Innovation Programme (GCIP), a competitive four-month business accelerator that provided structured mentorship, business model development, and market validation. Upon completion, AET Africa was awarded the Youth-Led Business Award—a recognition that came with additional visibility and credibility. This exposure attracted attention from investors and actors across the clean energy ecosystem, including the Department of Science and Technology and international media outlets.

Crucially, AET Africa secured commercialization funding from the Industrial Development Corporation (IDC) through its Technology Venture Capital (TVC) fund. This funding enabled the company to establish its own manufacturing facility after facing resistance from mainstream geyser manufacturers who were reluctant to partner on or license the new technology. However, despite receiving up to ZAR 10 million in commercialization support, the company still faced limitations due to high production costs and slow market uptake, which created challenges in managing cash flows.

Additional support also came from institutions such as the Council for Scientific and Industrial Research (CSIR), which provided tooling support and facilitated grassroots innovation programs. Entities like the Small Enterprise Development Agency (SEDA) and the Eastern Cape Development Corporation contributed logistical and technical assistance, while various university partners and technical consultants provided R&D and engineering expertise.

Together, these funding and support mechanisms were instrumental in helping AET Africa transition from a small startup into a notable innovator in South Africa's clean energy landscape. However, persistent challenges in certification, market access, and industry collaboration indicate that while funding was vital, complementary ecosystem support remains essential for long-term sustainability.

Market Access

Market access has been both a critical opportunity and a considerable challenge in AET Africa's clean energy journey. The company's flagship product, the Hotspot device garnered early interest from a diverse range of actors, including individual consumers, local retailers, and international partners. However, while demand existed, turning interest into consistent sales proved complex due to structural barriers within the market ecosystem.

AET Africa initially relied on independent distribution channels and small-scale installations to introduce its products to end users. The company partnered with local warehouses and deployed direct-to-consumer strategies, including online marketing and demonstrations. Retailers such as Ellis Brands also expressed interest, engaging in exploratory discussions about the product's potential. However, without standardized certification particularly South African Bureau of Standards (SABS) certification for the water heating device, these partnerships were difficult to formalize.

The company's efforts to collaborate with established geyser manufacturers were largely unsuccessful, as many of these incumbents viewed AET's innovations as disruptive to their traditional product lines. Despite numerous engagements and technical demonstrations, manufacturers hesitated to support or co-develop the product, often citing competitive concerns. This lack of industry endorsement significantly hindered AET's ability to scale through conventional value chains.

Internationally, AET Africa explored market opportunities in countries such as Ghana and Switzerland. Sample units were shared with prospective distributors, and there was demonstrable interest. However, the absence of certification again presented export challenges, as compliance with international product standards is typically a prerequisite for entry. This regulatory hurdle limited the company's ability to capitalize on global demand, despite being selected to represent South Africa in international innovation forums such as the Festival for Innovation and Entrepreneurship in India and the SA Venture Leaders program in Switzerland.

To navigate these constraints, AET Africa is now shifting its business model from manufacturing and direct sales to a licensing-based approach. This pivot aims to reduce overhead costs and allow established players in the market to adopt and distribute the technology under license. By focusing on intellectual property and forming strategic partnerships, the company hopes to circumvent barriers related to production, compliance, and large-scale distribution.

Overall, while AET Africa has demonstrated strong innovation and garnered significant attention in both domestic and international markets, its experience underscores the importance of certification, regulatory alignment, and industry collaboration for clean energy enterprises seeking to scale sustainably.

Gender dynamics

Gender dynamics at AET Africa reflect both the opportunities and challenges women face in the clean energy innovation space. As a woman-led enterprise, AET Africa is representative of gender inclusivity in leadership within a male-dominated sector. Sandiswa Qayi, the company's co-founder and Managing Director, has played a central role in conceptualizing, developing, and commercializing AET's flagship products. Her leadership has been instrumental in guiding the company through complex stages of innovation, from research and development to prototyping and seeking commercialization funding.

Sandiswa's journey itself challenges conventional gender expectations in the technical and manufacturing fields. Despite her background in social science and development studies—not engineering, she led the product development process, coordinated cross-disciplinary teams, and managed interactions with investors, manufacturers, and regulators. Her success illustrates the critical role of women in driving innovation, especially when empowered with access to networks, knowledge, and capital.

However, systemic gender barriers have still affected the company's operations. One challenge has been the perception of women in leadership roles within the industrial sector. As Sandiswa recounted, navigating male-dominated supplier relationships, manufacturing negotiations, and regulatory engagements often involved overcoming skepticism or condescension. In some instances, gender biases influenced the responsiveness of actors, particularly in discussions requiring technical validation.

Challenges encountered

Key challenges identified during the interviews include certification and compliance barriers, material quality control, high machinery costs, and limited access to large-scale manufacturers unwilling to adopt disruptive innovation. IP-related challenges and high operational costs also affected scalability.

Establishing AET Africa came with a series of complex and resource-intensive challenges that significantly shaped the company's early journey. One of the initial setbacks was the limited understanding of intellectual property rights and patent procedures. While the product concepts were novel, the lack of early knowledge on IP protection meant that opportunities to secure design patents were missed, exposing the innovations to potential replication without legal safeguards.

Sandiswa mentioned that “....we were doing the patent, we realized it's a novel idea. So, we went through with the patent, but as I said, we were more focused on the concept and by that stage, our design was already out there. So, we couldn't patent on the design aspect. So, we didn't know much. Yes, we had a little knowledge about IPs and all of that, but by the time we got to that module, when we were doing the accelerator, we were already out there. So, it was one of those lessons that maybe we needed to also know more about the patent before we start.”

Another critical challenge involved sourcing appropriate materials for the HotSpot device. Because the unit is installed inside household water heaters, ensuring safety for human use was paramount. Identifying materials that were both heat-resistant and safe for consumption proved difficult. The team spent months sourcing suppliers, and in some cases, large financial investments were lost on material batches that failed to meet the required specifications.

Sandiswa explained that “We spent a lot of time doing research in terms of the materials that we needed because remember now, this leaves goes inside the water tank. So, meaning people will use the water that comes from the Yerkes for consumption and you needed something that's not going to cause skin irritation or cause any diseases and all of that. So, that was also a new terrain that we had to navigate. We realized that the material doesn't meet the specification and the manufacturer was not willing now to manufacture or do the batch or mix it for us for commercialization. So, we had to start the process from scratch, spend six months running around, going to Europe, speaking to suppliers with the right grade from France, Germany. I don't even know how many countries we had to reach out. And every time you phone them, they will ask all the technical questions from your viscosity, things that I didn't even know about. So, we had to take a step back, again, look for specialists within the material space. So, that also took or delayed the process. I think, as I said, about six months. At some stage, we bought the first batch of some of the ingredients because now we had to mix our own ingredients, work out our own formula and all of that and get someone to do that for us. The first batch of material we bought was the wrong grade.”

Certification proved to be one of the most persistent barriers. Efforts to obtain the South African Bureau of Standards (SABS) certification faced repeated setbacks, mainly due to the absence of an applicable standard for the product category. This lack of certification became a major bottleneck, preventing AET Africa from scaling up operations, exporting to other markets, or securing large institutional buyers. Although AET Africa managed to attract customers willing to purchase the product, many were taking a significant risk due to the absence of a warranty backed by SABS certification. In an effort to build trust and credibility, the company sought partnerships with certified installers and even joined industry associations to gain endorsements. This process, however, was both time-consuming and financially demanding. After nearly a year of engaging with one such institution, AET Africa was informed that the association could no longer support the program or act as installers. Their reasoning was rooted in concerns about jeopardizing existing relationships with major geyser manufacturers.

Sandiswa explained that “We had customers, yes, that were buying the product, but they were taking the risk because we didn't have the warranty if there's no SAPS certification. We had to look for a lot of partners in terms of your installers, join their association, get them to endorse the product. That was another journey, and it costed us money. And later, I think 12 months later, being the member of the institution, they came back and said, nope, we can't run with this program or sell it or become the installers because now we'll be revoking our own relationship with the biggest geyser manufacturers. So, that was another stumbling block.”

Moreover, established industry players viewed AET Africa as a market disruptor. Geyser manufacturers and other actors were reluctant to collaborate, often citing conflicts of interest with their own innovation pipelines. This resistance made it difficult for the company to penetrate mainstream distribution channels. This experience underscored a major challenge: the clean tech industry's entry barriers, particularly around certification and compliance, were exceedingly high. AET Africa was perceived as a disruptive force, and despite persistent efforts to demonstrate value, institutional resistance remained a major obstacle to broader market acceptance.

From a financial perspective, while AET Africa successfully raised funding for research and development, the costs associated with commercialization exceeded available resources. Operational expenses, particularly for staffing and production, were high, and inventory turnover was slower than needed to maintain cash flow. This misalignment between scale, cost, and demand further constrained the company's ability to achieve sustainable growth in its early years.

Sandiswa highlighted that “We had funding, as I said, especially for the R&D, but where we were limited as much as we had the commercialization funding, what AET could go up to was like 10 million. in order for your factory to be successful, there's a minimum protection run that you need to meet so that you can manage your operational costs. We had staff. I mean, at some stage, we're even employing about 60 people within my factory. So, now the issue is that the more you produce, you try and sell, but the numbers are not telling up to your operational costs because the inventory was not moving as fast as what we needed for us to have like a cash flowing in, I mean, to balance your cash flows. So, that was another issue.”

Although AET Africa was able to secure funding, particularly for research and development, commercialization support remained limited. While they received up to 10 million ZAR, this amount was insufficient to sustain full-scale manufacturing. Operating a factory requires meeting a minimum production threshold to cover operational expenses, including salaries and utilities. At one point, the company employed as many as 60 people, which further amplified overhead costs. However, despite increased production efforts, sales volumes did not keep pace with output. This mismatch led to slow inventory turnover, which in turn hindered cash flow and made it difficult to balance financial obligations, posing a significant challenge to the company's sustainability.

Conclusion

AET Africa provides a case through which to examine the systemic factors that shape the success and scalability of youth- and women-led clean energy enterprises (CEEs) in South Africa, aligning closely with the overarching objectives of the EVI-SICEE project. AET's journey rooted in local innovation and led by a woman entrepreneur illustrates both the potential and the persistent challenges faced by emerging enterprises in the clean energy space. Despite its novel retrofit technologies designed to reduce electricity costs and promote energy efficiency, AET Africa encountered numerous barriers, including limited access to certification, high operational and commercialization costs, difficulties accessing large-scale markets, and resistance from established industry players.

These challenges underscore the structural constraints that can inhibit the growth of promising CEEs, even when they are supported by strong ideas and early-stage funding. However, AET's resilience, combined with targeted support from public institutions, mentorship programs, and international exposure through award platforms, demonstrates the key role of ecosystem-wide support in fostering inclusive entrepreneurship. In line with the EVI-SICEE project objective to inform the optimization and scaling of youth and women-led CEEs, the AET case reinforces the need for enabling policy environments, gender-sensitive support structures, affordable and accessible financing, and streamlined regulatory pathways. It also highlights the importance of investing in leadership capacity, innovation development, and inclusive business models that prioritize long-term impact over short-term gains. This case study offers valuable insights for policymakers, donors, and practitioners working to scale inclusive clean energy solutions across Kenya, Malawi, Uganda, and South Africa.

Evidence for informing optimization and scaling of youth and women-led CEEs and business models in Kenya, Malawi, Uganda & South Africa

Kaeane Renewable Energy Developers
CASE STUDY REPORT

University of Johannesburg, South Africa



Canada

Introduction

This case study is part of the broader research effort under the Evidence for Informing Optimization and Scaling of Youth and Women-Led Clean Energy Enterprises and Business Models in Kenya, Malawi, Uganda, and South Africa (EVI-SICEE) project. The project aims to understand the systemic factors that enable or hinder the success and scalability of clean energy enterprises, particularly those led by women and youth. It also seeks to identify best practices that can be leveraged to promote clean energy innovation, investment access, and sustainability across diverse African contexts. This specific case study focuses on Kaeane Renewable Energy Developers, a Lesotho-based clean energy enterprise operating in the biogas sector, included as a regional comparative case relevant to the broader EVI-SICEE research programme.

Background

Kaeane Renewable Energy Developers is a Lesotho clean energy enterprise specializing in the development of biogas solutions from organic waste, see Fig. A5.2. The company was founded over five years ago and is currently led by CEO Mr. Letsoela Bennett Nkhasi. Since its establishment, Kaeane has focused on providing sustainable and practical energy alternatives through the conversion of biodegradable materials into biogas for heating, cooking, and lighting applications. At the core of Kaeane's operations is the utilization of organic waste - primarily from households and farms to construct fixed dome biogas digesters. These systems are tailored to various settings, including residential homes, schools, communal kitchens, guest lodges, and commercial farms. By targeting both individual and institutional consumers, the enterprise is addressing critical energy access gaps while promoting environmentally friendly waste management practices.



Figure A5.2 a & b: Biogas digester under construction by Kaeane Renewable Energy Developers.

Source(<https://www.facebook.com/photo.php?fbid=1287469606721068&set=pb.100063741232030.-2207520000&type=3>)

Through its targeted deployment of biogas technologies, Kaeane plays a key role in advancing clean energy access in South Africa's semi-urban and rural areas. The company's inclusive model not only serves energy needs but also contributes to climate mitigation by reducing reliance on traditional biomass fuels and lowering greenhouse gas emissions from unmanaged organic waste. This background situates Kaeane as a promising actor in the clean energy ecosystem, particularly in relation to the goals of the EVI-SICEE project, which seeks to identify and support scalable, youth- and women-led clean energy business models across sub-Saharan Africa.

Motivation to start the business

The establishment of Kaeane was primarily driven by the founders' desire to correct and improve upon previous failed biogas initiatives in their community. Mr. Nkhasi, the company's CEO, explained that prior to Kaeane's inception, several companies had attempted to introduce biogas systems in the area. However, these early initiatives were largely unsuccessful. Many systems installed were misrepresented as biogas-producing digesters but functioned merely as septic tanks, failing to generate any usable gas. Moreover, the infrastructure was often substandard, with issues such as leaks and incomplete installations, which ultimately led to widespread disappointment and a loss of public trust in biogas technology. Witnessing the growing number of dissatisfied community members and failed projects, the Kaeane team identified a critical gap: the need for a reliable, research-driven biogas solution that could deliver tangible and effective results. Their motivation stemmed from a commitment to restoring credibility to clean energy technologies in their region and providing communities with systems that genuinely worked. The company set out to design and implement biogas systems based on sound technical foundations, rigorous research, and customer trust.

By ensuring their systems produce actual gas for cooking, lighting, and heating, Kaeane aimed not only to address the unmet energy needs of households, schools, farms, and lodges but also to reverse the negative perception around biogas and contribute meaningfully to the clean energy transition in South Africa.

Business model and operations

Kaeane operates as a self-financed, independently managed clean energy enterprise. The company does not currently have external partners, investors, or actors contributing financially or strategically to its operations. Instead, it relies entirely on internally generated resources and income from completed projects to sustain and grow the business.

Mr. Letsoela explained that "We don't have partners yet. We don't have any investors or actors that are available. And yes, we just use our sales and marketing. We just used our marketing department to advertise us and talk about us. Then after that, we solidify customers. Then we do site visits. And from there, we send quotations. And if the client is satisfied, we start work."

The company follows a simple operational model. Its marketing efforts are handled in-house, with the team actively promoting their services through outreach and local engagement to raise awareness about their biogas solutions. Once interest is generated, the company engages with potential clients through site visits to assess the feasibility and needs of each location. Based on the site assessments, they prepare and share quotations with prospective customers. Upon acceptance, Kaeane proceeds with the installation of biogas systems tailored to the client's energy needs. This streamlined, customer-focused process driven by direct marketing, technical evaluation, and client customization, has allowed the company to build trust and maintain autonomy while fulfilling its mission of expanding access to clean energy in rural and semi-urban areas of South Africa.

Key capabilities required for business expansion

In considering the future growth and scaling of Kaeane, several critical capabilities and skill sets have been identified as essential to support expansion efforts. These include:

- **Electrical engineering expertise** - The technical nature of biogas system design, installation, and optimization requires in-depth electrical engineering knowledge. Access to skilled electrical engineers would enhance the company's ability to innovate, ensure system efficiency, and manage more complex installations across various sites.
- **Graphic design and branding skills** - To strengthen the company's market presence and customer outreach, graphic designers are seen as crucial in creating compelling marketing materials, improving brand identity, and communicating the company's value proposition more effectively to a broader audience.
- **Information Technology (IT) Support** - As digital infrastructure becomes increasingly central to modern business operations, the inclusion of IT professionals would facilitate the development of digital tools for project tracking, customer engagement, and operational management. IT support would also enable the adoption of smart energy monitoring systems and potentially support remote diagnostics for biogas units.

These skill sets are viewed as instrumental for Kaeane to scale effectively, increase their market reach, and enhance operational efficiency while maintaining high standards in service delivery.

Key challenges experienced

Kaeane has faced a few critical challenges since its inception, which have shaped its operational strategies and business model. One of the foundational challenges was a lack of financial capital at startup. Without external investors or partners, the company relied entirely on self-financing, which limited their ability to scale operations rapidly or invest in advanced equipment and personnel during the early stages.

Another major hurdle stemmed from a climate of mistrust within the market, largely caused by earlier biogas installers who failed to deliver functioning systems. These failed implementations created skepticism among potential clients, requiring Kaeane to invest heavily in building community trust, demonstrating system functionality, and offering guarantees on service delivery to differentiate themselves from past operators.

Mr. Letsoela highlighted that "...the reputation about biogas was already negative. So it was really hard for people to now trust and give it a chance again to believe that this time around the company that is doing this, it will get the same results. Because already people were having complaints and there was a reputation about this thing as being a scam."

Client payment issues have also presented persistent difficulties. In several cases, customers delayed payments after services were rendered or failed to pay the remaining balance altogether. This impacted the company's cash flow and strained its ability to cover operational expenses and staff wages. To address this, the company introduced formal financing and payment policies, including contractual agreements that enforce a penalty fee for late payments beyond five days post-completion. This has helped to mitigate financial risk and ensure more predictable revenue flows.

Mr. Letsoela said that "And then after the completion of the work, then it comes that the customer now is taking that time to pay us the full amount. So we encountered such challenges that the customers would delay. Some of them would not even pay, like we have this one that has not even paid even till today. So we've worked, they just paid the initial 50% and they have not paid."

These challenges reflect the realities of operating a clean energy enterprise in a developing and trust-sensitive market, and they underscore the importance of robust financial planning, community engagement, and legal safeguards in ensuring business sustainability.

Business support

Kaeane has benefited from various forms of institutional support, particularly through incubation programs aimed at strengthening small and emerging enterprises in the renewable energy sector. A key source of such support has been Prime Cubate, an incubation hub that the company engaged with to enhance its operational and strategic capabilities.

Mr. Letsoela mentioned that “We have received support from an incubation hub...Prime Cubate...They help us with marketing, they help us with financial records, they help us with management.”

Through Prime Cubate, the enterprise received comprehensive training across multiple domains essential for business growth and sustainability. This included marketing support, which helped the company improve its outreach and visibility within potential markets; financial training, which focused on establishing sound bookkeeping and financial management practices; and management development, equipping the leadership with skills for effective decision-making, team coordination, and business planning. The engagement with Prime Cubate has played a critical role in building the company’s internal capacity, particularly in navigating the operational complexities of the clean energy sector, and in laying the groundwork for future scaling and investment-readiness.

Gender dynamics of the business operations

At Kaeane, gender inclusivity is reflected in the company’s approach to work and leadership. According to the CEO, task allocation is strictly based on capability and competence, regardless of gender.

Mr. Letsoela said that “Whoever has the capacity to do the job does the job.”

This principle is evident in the company’s management structure, which maintains a balanced gender composition of three men and three women. The leadership team is not only gender-diverse but also intergenerational, with a mix of youth and older individuals contributing a range of perspectives and experiences. Such inclusivity promotes shared decision-making and enhances the organizational culture, allowing the company to benefit from a broad set of skills and leadership styles. This alignment with gender-equitable practices is significant within the context of EVI-SICEE’s focus on youth and women-led clean energy enterprises, highlighting Kaeane’s role in modeling inclusive business leadership in the renewable energy sector.

Conclusion

The case study of Kaeane highlights a compelling example of a youth-led enterprise striving to offer reliable and impactful clean energy solutions in South Africa’s biogas sector. Motivated by a clear desire to address the technical and credibility failures of earlier initiatives in the region, the enterprise has emerged with a mission to deliver functioning, sustainable biogas systems to households and institutions. Through targeted innovations and community trust-building, Kaeane aims to correct past deficiencies and offer clean energy alternatives that genuinely improve livelihoods.

The company’s engagement with business incubation support, particularly through Prime Cubate, has helped strengthen its managerial, marketing, and financial capacities. Additionally, its inclusive approach to gender in management and operations demonstrates a progressive organizational culture aligned with equity and merit.

Despite ongoing challenges such as access to capital and limited awareness of biogas technology Kaeane continues to push forward, addressing systemic gaps with practical solutions and community engagement. Its journey reflects the core objectives of the EVI-SICEE project, which seeks to identify and support scalable, youth and women-led clean energy business models. As such, Kaeane provides important insights into what works, what remains difficult, and what opportunities exist for scaling clean energy entrepreneurship in the African context.

Evidence for informing optimization and scaling of youth and women-led CEEs and business models in Kenya, Malawi, Uganda & South Africa

KUSINI WATER CASE STUDY REPORT

University of Johannesburg, South Africa



Canada

Background

Kusini Water is a pioneering social enterprise based in South Africa dedicated to addressing water insecurity by delivering safe, clean drinking water to underserved communities. At the heart of its mission is a commitment to environmental sustainability, social impact, and technological innovation. The organization operates through a multi-pronged approach, utilizing advanced water purification systems such as Reverse Osmosis (RO) and Ultrafiltration (UF) technologies (see Figure A5.3 & 4), which are deployed via mobile trailers (see Figure A5.3) and stationary kiosks across the country.



Figure A5.3: Kusini water mobile trailer kiosk.

Kusini Water's systems are designed with flexibility in mind. They utilize hybrid power sources, running on both solar energy and conventional municipal electricity. This adaptability enables the enterprise to function effectively in areas with limited or unreliable power infrastructure, making it a resilient and scalable solution to water access challenges in South Africa.



Figure A5.3: Kusini water filtration system combining solar, reverse osmosis and ultrafiltration technologies.



Figure A5.4: Kusini water filtration system with reverse osmosis and ultrafiltration technologies.

Oratile Tlhabanyane, the Technical Operations Lead, plays a vital role in streamlining Kusini Water’s digital processes and currently leads a project to integrate Point-of-Sale (POS) systems across the organization’s water kiosks. These kiosks form a central part of Kusini Water’s model: once installed, local community members—trained as “water champions”—are empowered to manage and operate the kiosks, thus ensuring community-based ownership and sustainability of water services.

By combining cutting-edge water purification technology with social entrepreneurship and community empowerment, Kusini Water embodies the principles of inclusive development and environmental stewardship, serving as a leading model in the clean tech and water innovation space.

Motivation for Founding Kusini Water

The founding of Kusini Water was driven by a commitment to solving the persistent issue of water insecurity in rural and underserved communities in South Africa. Murendeni Mafumo, the company’s CEO, previously worked as a water engineer with the City of Cape Town. Despite his role in a major metropolitan municipality, he felt disconnected from the real impact of his work on the ground—particularly in the rural communities similar to his own upbringing in Limpopo, where residents often fetched water from streams due to lack of safe, accessible sources.

Motivated by the desire to create meaningful change in the lives of people in marginalized areas, Murendeni made the bold decision to leave his formal engineering position in the public sector to establish Kusini Water in 2016. His vision was to design a practical, scalable solution to the clean water crisis using innovative technologies and community-based approaches.

Oratile mentioned that “... Murendeni wanted to make an impact to communities like his and villages like his. And that’s why he left the city of Johannesburg, to be correct, the city of Cape Town to start this water company.”

Kusini Water embodies his mission to directly uplift communities by combining solar-powered water purification systems with local entrepreneurship, thereby addressing both environmental and socio-economic challenges in tandem.

This personal and socially rooted motivation continues to be the cornerstone of Kusini Water's operations, reflecting a broader commitment to equitable access to resources and inclusive development across South Africa.

Key challenges

While making significant strides in enhancing access to clean and safe drinking water for underserved communities, Kusini Water has encountered some operational and strategic challenges along its journey.

a) Access to quality water champions (entrepreneurial talent)

A key challenge lies in identifying and training suitable individuals, referred to as "water champions" who not only understand the importance of providing clean water but also possess the entrepreneurial mindset necessary to run and sustain water kiosks effectively. While many individuals who enroll in the Water Champions Program have a genuine need for clean water in their communities, they often lack the foundational business skills and traits required to operate the kiosks as viable micro-enterprises.

Oratile explained that "...access to quality water champions. Because what we want is we want to have waterpreneurs. People that have a business mindset. And they will be able to run this water kiosk while also providing water for their communities. So, people that come through, there are people that come through the Water Champions Program. There are people that have a need for water. But they don't necessarily know how to run a business."

This disconnect between community need and entrepreneurial readiness presents a recurring challenge in scaling Kusini Water's impact sustainably.

b) Capacity constraints and infrastructure limitations

As Kusini Water expands its projects and national footprint, it has faced internal capacity limitations. The rapid growth of the organization, including a continually expanding team, has outpaced its current infrastructure. This has necessitated the move to a larger facility to separate office functions from manufacturing operations.

Oratile highlighted that "Another challenge I would say is capacity. Because we have so many projects, office capacity, our team is getting bigger each week. We actually just got another supply chain intern."

The lack of adequate physical space to accommodate both administrative and production activities has created inefficiencies and operational bottlenecks, underscoring the need for infrastructural investment to support future growth.

c) Solar infrastructure theft in disadvantaged communities

A major challenge identified by Kusini Water is the theft of solar equipment in rural and underserved areas. Although solar power offers substantial benefits, such as reducing electricity costs and enhancing the sustainability of water purification systems, the frequent theft of solar panels has become a deterrent.

Oratile mentioned that "...in communities that are disadvantaged, we have a lot of theft going on. So, us using solar at such communities brings a lot of theft going on. So, that's why sometimes most, if not, let's say most of our kiosks, especially in these villages, we use normal electricity. Because we put installation next week, solar is gone...that's how we would change our actual system and made it hybrid."

In several instances, solar installations are stolen within days, undermining investments and limiting the ability to rely solely on renewable energy. This has led Kusini Water to transition toward hybrid systems that incorporate both solar and municipal electricity, allowing for flexibility while mitigating the risk of total service disruption due to theft.

d) Dependence on unreliable public infrastructure

While water scarcity may not be acute in all regions, access to clean water is often impeded by failing infrastructure. Communities frequently experience issues such as burst pipes and delayed maintenance, which prevent consistent water delivery despite the presence of sufficient water sources. This creates a paradox where the availability of water does not translate into accessibility, especially in rural or peri-urban areas. Kusini Water must constantly navigate these systemic weaknesses in South Africa's public infrastructure, adapting its technologies and service models accordingly.

Oratile said that “...infrastructure in South Africa when it comes to the water challenges. Because then I think we would believe that there is water, but then people are not getting the right access to it because of the infrastructure...pipes are bursting every two seconds. It's not because there's no water.”

Together, these challenges highlight the importance of continuous investment in human capital development, infrastructure expansion, flexible technological models and secure energy infrastructure to ensure that Kusini Water can sustain and scale its innovative model for community-based water access.

Business Support and Capacity Development

Kusini Water has experienced significant business growth and capacity expansion through a combination of strategic partnerships, financial investments, and targeted development support. One of the company's most notable milestones was securing a Corporate Social Responsibility (CSR) contract with Nedbank in 2023. This partnership enabled Kusini Water to deploy 40 water kiosks across South Africa, significantly increasing its community reach and visibility. The impact of this collaboration was so substantial that the contract was renewed in 2024 for an additional 40 kiosks, making it the company's largest deployment initiative to date.

Oratile said that “So, we got a contract with NedBank CSI in 2023. We were able to deploy 40 kiosks and that was our biggest contract still is. So, 2023, 2024 again, we renewed that same contract where we deployed another 40.”

Kusini Water operates through two complementary entities: Kusini PTY, which handles the technical and manufacturing components, and Kusini Foundation, which leads the impact-driven initiatives. The foundation receives funding from various grant sources and corporate partners such as Beverage of South Africa, the U.S. Embassy, New Zealand, and ABSA as part of their CSI strategies. These funds are used to support community access to clean water through social entrepreneurship models. The foundation then contracts Kusini PTY to manufacture and deploy the necessary technology.

Oratile explained that “...we have Kusini PTY and Kusini Foundation. So, Kusini Foundation is the one that drives the impact and then Kusini PTY, we are the ones that are manufacturing. So, NetBank, for example, was one of the clients where we have NetBank, we have Beverage of South Africa, used to work with US Embassy, New Zealand, ABSA. So, there's quite a lot of business support that we're getting. So, it's their CSR strategy to support Kusini Foundation and Kusini Foundation contracts with Kusini PTY to help with the manufacturing. ...we do have one of our investors called Edge Growth, they have a business coach. He would come here every quarter, help us through our quarterly goals, whether we want cultural support. So, we do get other than financial, yeah.

In terms of non-financial business support, Kusini Water benefits from strategic guidance and coaching through its investor, Edge Growth. The organization provides a quarterly business coach who works closely with the Kusini team to help align quarterly goals, support organizational culture, and offer mentorship. This has proven instrumental in building a sustainable operational model and refining internal processes.

Conclusion

The case study of Kusini Water offers critical insights into how innovative, socially driven enterprises can address pressing water access challenges in South Africa through clean and sustainable technologies. Founded with a deep-rooted personal motivation to uplift underserved communities, the enterprise has grown into a dynamic organization combining technical innovation, social impact, and business sustainability. By leveraging hybrid water purification systems and empowering local “water champions” through training and micro-franchising, Kusini Water not only delivers clean water but also fosters local entrepreneurship and resilience.

Despite facing challenges such as limited business acumen among community entrepreneurs, capacity constraints due to rapid growth, and infrastructure vulnerabilities like solar panel theft, Kusini Water has demonstrated adaptability and scalability. Strategic partnerships, such as those with Nedbank CSI, Edge Growth, and other development actors, have been instrumental in enabling the enterprise to scale operations, improve internal systems, and extend its reach across South Africa.

From a broader perspective aligned with the EVI-SICEE project objective, Kusini Water exemplifies how youth-led clean energy enterprises can overcome systemic barriers through a combination of technical innovation, social enterprise models, and multi-actor support. The company’s emphasis on localized solutions, inclusive business models, and sustainable impact serves as a replicable blueprint for other youth and women-led enterprises across Africa. Strengthening such models through targeted capacity building, infrastructure support, and policy alignment will be critical to accelerating clean energy access and achieving sustainable development outcomes at scale.

Evidence for informing optimization and scaling of youth and women-led CEEs and business models in Kenya, Malawi, Uganda & South Africa

Tshilidzi Tshawe (His grace) Cooperative
CASE STUDY REPORT

University of Johannesburg, South Africa



Canada

Introduction

This case study provides details of Tshilidzi Tshawe (His grace), a rural-based enterprise in South Africa that integrates agriculture with renewable energy - specifically biogas. The cooperative is youth-led and inclusive, with both male and female participation. While their core focus remains agriculture, they have increasingly become engaged in the maintenance of biogas digesters and community awareness around clean energy technologies. The case highlights systemic factors influencing market access, business viability, and opportunities for youth-led CEEs in South Africa.

Background and motivation

Tshilidzi Tshawe Cooperative is a rural-based enterprise primarily focused on agricultural production, particularly the cultivation of vegetables for local communities. In parallel to its core agricultural activities, the cooperative has actively engaged in maintenance of biogas digesters within the local community. Although biogas is not yet a dominant focus of the business, Tshilidzi Tshawe has positioned itself at the intersection of agriculture and clean energy by participating in capacity-building initiatives. The cooperative is a partner in a programme in collaboration with Professor David Tinarwo (Associate Professor in the Department of Physics and leader of the Biogas Research team at the University of Venda), which provides training and support for the maintenance of community-based biogas digesters.

Through this engagement, the cooperative has expanded its technical capabilities and contributed to the ongoing functionality of clean energy systems within rural households. While agriculture remains the principal economic activity, this dual involvement signifies a strategic transition toward integrated, sustainable farming and energy solutions.

Thilivhali Eugene Rasimpi, the director of TshilidziTshawe grew up in a rural community where firewood was the primary source of energy for cooking and heating. In June 2023, Eugene was highlighted as the [Youth of the Month by the National Research Foundation \(NRF\)](#), which highlighted young researchers contributing to knowledge advancement and social transformation. Eugene is a Doctoral candidate in Rural Development at the University of Venda, who has benefited from NRF funding for both his Master's and PhD studies, exemplifying the NRF's role in supporting emerging scholars driving positive change in South Africa.

His introduction to biogas technology sparked an awareness of its potential as a sustainable alternative to firewood and electricity.

Eugene explained that “Growing up in a rural village, mostly we used firewood to do the cooking, the eating, and when I was introduced to biogas technology, I realized that this is something that it has been there, and one can actually use it to supplement firewood or electricity, and yeah, that has been my main motivation to say one can actually move from using firewood to using energy source, which is biogas.”

Motivated by this realization, he became actively involved in promoting biogas as a solution that reduces environmental degradation and offers rural households cleaner, more efficient energy options. This personal motivation evolved into professional engagement through TshilidziTshawe, which combines agricultural activities with the promotion and maintenance of biogas systems.

Business model and operations

Tshilidzi Tshawe, operates a hybrid model, combining farming with biogas maintenance and awareness. The enterprise participates in rural awareness campaigns, supports the maintenance of biogas digesters, and makes use of bioslurry for farming. Although the business has not yet scaled into full biogas production, it plays a critical role in bridging the knowledge and technical service gaps in rural communities.

The cooperative currently operates without a website and has no external financing. Most activities are funded internally by the directors. However, the business has been actively involved in development programmes such as those led by Professor Tinarwo which provide technical training and mentorship.

Key challenges

a) Limited access to capital

Access to capital remains a significant constraint for TshilidziTshawe Cooperative, particularly in sustaining and scaling its clean energy initiatives. Since its inception, the business has relied entirely on internal financing from its directors, with no external funding support. This self-financing model limits the cooperative's ability to fully engage in essential activities such as field visits, client outreach, and awareness campaigns—core components necessary for promoting biogas technology in underserved rural areas.

Eugene mentioned that “We haven't received any outside finance. From the business side, you can't run a business without that capital to travel, do visits, do awareness, so we have to depend on the programme to do those, so the capital access, is quite a challenge.”

While programmatic support such as training and mentorship from the Professor Tinarwo initiative has been instrumental, it does not address the ongoing need for working capital required to execute day-to-day business functions and expand service coverage. The cooperative remains heavily dependent on these external programs for non-financial support, which, though valuable, cannot substitute for the liquidity needed to grow and sustain a clean energy enterprise. This gap in capital access not only restricts operational activities but also hinders strategic investments in infrastructure, marketing, and staff hiring therefore constraining the enterprises' ability to scale and optimize.

b) Low market penetration

One of the most significant challenges faced by Tshilidzi Tshawe Cooperative in promoting biogas technology is limited market awareness and acceptance. Biogas remains relatively unfamiliar in many rural communities, making it difficult for CEEs like Tshilidzi Tshawe to introduce and scale the technology. The immaturity of the market poses further constraints, especially when seeking financial support from traditional institutions. As Eugene Rasimpi, Director of the cooperative, explained, financial institutions often lack understanding of the biogas sector, which makes it difficult for businesses to secure funding for expansion or implementation of new projects.

Eugene highlighted that “...most people don't know about the technology. If you go to banks and you say you want to start a project on biogas technology, it's quite difficult, so let them know, but biogas, the market is not yet mature, so it's very difficult to actually penetrate. Engagement with the program led by Professor Tinarwo is really helpful, because we get to travel to different communities, host awareness campaigns, introduce the technology, show the people what it does, how it operates, and fortunately enough, some were selected in the previous projects to can actually have digesters, so we go there now and again to actually assist them in the challenges that they're facing.”

To overcome these barriers, the cooperative has leveraged its involvement in the Professor Tinarwo's program, led by Professor Tinarwo. This initiative has played a crucial role in expanding the cooperative's outreach and credibility. Through structured training and community-based awareness campaigns, Tshilidzi Tshawe has been able to travel to various rural areas to educate households on the benefits of biogas, demonstrate how digesters function, and support existing users in system maintenance. These efforts are gradually breaking down misconceptions and building local confidence in biogas as a viable energy solution, laying the groundwork for deeper market penetration in the future.

a) Misconception of biogas viability

One of the core challenges faced by Tshilidzi Tshawe cooperative in advancing its clean energy mission lies in the persistent misconceptions surrounding the viability and relevance of biogas technology. As a relatively underutilized and poorly understood solution in many rural communities, biogas is often viewed with skepticism. According to Director Eugene Rasimpi, many people perceive biogas as an impractical or nonviable business idea, believing that "it won't go far" or that "there's no business" in it. These doubts are not only prevalent among potential users but also influence key actors such as financial institutions, which further complicates efforts to gain traction in the market. Such misconceptions create a psychological and social barrier that discourages both demand-side adoption and supply-side investment in biogas technology.

Eugene explained that "since the technology is still trying to find its way through. So, the misconceptions there are that it won't go far, there's no business. But I believe that this can be changed with a different approach. Obviously, it needs to take root and grow strongly. That's where the misconceptions are, but they can be uprooted. Through this program, I believe they're being uprooted, because we've encountered quite a few people who are saying that they do need the digesters in their homesteads. So, through that, you can actually see that the misconception, little by little, it's being treated away..."

However, Rasimpi remains optimistic that this narrative can be reversed. Through targeted community engagement and awareness-raising activities—largely enabled by their involvement in programs like the one led by Professor Tanaro—the cooperative has begun to shift public perception. By demonstrating the technology's functionality and benefits through practical installations and maintenance services, the team is gradually building trust and acceptance among households. Rasimpi notes, pointing to growing interest as evidence that misconceptions are slowly being eroded. While the biogas sector may still be in its early stages, consistent grassroots engagement and tailored communication strategies are proving effective in fostering a more informed and open-minded market for clean energy solutions.

Business Support and Capacity Development

Business support and capacity development have played an important role in strengthening Tshilidzi Tshawe Cooperative's ability to navigate the clean energy sector, particularly in biogas technology. As highlighted by Eugene Rasimpi, the cooperative's involvement in ["Promoting organic waste-to-energy \(WtE\) and other low-carbon technologies in small and medium and micro-scale enterprises \(SMEs\): Accelerating biogas market development in South Africa."](#) project led by Prof. David Tinarwowa at the University of Venda. The capacity building programme has been instrumental in equipping the team with a diverse set of skills essential for running and sustaining a clean energy enterprise. The programme provided comprehensive training that combined technical and business competencies. On the technical front, the team received hands-on instruction in the maintenance, operation, and construction of biogas digesters, enabling them to offer reliable services to communities while building credibility in the sector. This technical grounding is crucial in a market where quality service delivery can help overcome skepticism and build trust in biogas solutions.

In parallel, the programme offered critical business and soft skills development. This included guidance on general business management practices, such as planning, operations, and customer relationship management. Participants also gained expertise in crafting and delivering compelling business pitches and presentations, a skill set that is essential for securing funding, forming partnerships, and promoting technology adoption. The training emphasized strategies for engaging effectively with potential clients and actors, teaching participants how to articulate the benefits of biogas technology and address common concerns or misconceptions.

Eugene highlighted that “Through Prof. Tinarwo’s programme, we received training on business in general, how one can run a successful business through technical skills in terms of maintenance, operation, construction of digesters and also some soft skills in terms of putting up a pitch, a presentation, engaging with customers, how you can actually convince them to take the technology and what strategies can you use to actually convince them.”

Collectively, this business support and capacity development have enhanced the cooperative’s ability to communicate its value proposition, deliver quality services, and position itself for future growth. Such support highlights the importance of integrated capacity-building initiatives in enabling youth-led CEEs to overcome barriers and scale operations.

Gender dynamics

At Tshilidzi Tshawe Cooperative, gender inclusivity is a key value embedded in the organization’s structure and daily operations. As described by Eugene Rasimpi, the cooperative ensures that both men and women have equal opportunities to participate in decision-making processes and contribute to the strategic direction of the business. This inclusive approach allows male and female members alike to engage actively in discussions, propose ideas, and help shape the cooperative’s activities, whether in agriculture or biogas technology.

Eugene said that “...both males and females are given that opportunity to actually decide on the approach on any activity. Both men and women are given the same opportunity to engage and discuss.”

By promoting a collaborative environment where voices are valued equally regardless of gender, the cooperative exemplifies the principles of gender equity that are essential for building resilient and representative CEEs. This balanced participation not only strengthens internal cohesion but also sets an example for how inclusive leadership can enhance innovation and problem-solving, in women or youth-led clean energy initiatives.

Climate change impact

Climate change presents both a barrier and an advocacy opportunity for Tshilidzi Tshawe Cooperative. It has presented both challenges and opportunities for Tshilidzi Tshawe Cooperative in its efforts to integrate biogas technology with agricultural practices. On the negative side, changing weather patterns, particularly increased rainfall, have disrupted key operational activities. As Eugene explains, heavy rains hinder the cooperative’s ability to collect feedstock needed for biogas digesters, limiting the consistency of operations and making it difficult to maintain digesters effectively during certain periods.

Eugene said that “Climate change has had a negative influence, if it's raining, you can't actually go to the field and collect the feedstock to assist in feeding, so it becomes quite a challenge. The positive is that this is an opportunity. You can actually tell someone that when you are actually cutting down trees, you are contributing to climate change, so instead of cutting down trees, you can actually use the available resources (biogas) that are there, and then generate energy. So, positive and negative effects.”

However, these climate-related challenges have also opened up important advocacy and awareness opportunities. The cooperative uses its platform to educate communities on the connection between deforestation, reliance on firewood, and climate change. By highlighting biogas as a sustainable alternative energy source, they encourage households to reduce tree-cutting and adopt cleaner, climate-friendly solutions. In this way, climate change serves as both a barrier to daily operations and a catalyst for deeper community engagement on the benefits of renewable energy technologies.

Opportunities for scaling

Tshilidzi Tshawe Cooperative recognizes several emerging opportunities that could support the scaling of its clean energy initiatives, particularly in the biogas sector. As Eugene noted, institutions such as the Technology Innovation Agency (TIA) and Ned bank are beginning to offer funding schemes specifically designed to encourage companies operating in the clean tech space. These funding opportunities provide a critical pathway for youth-led enterprises like Tshilidzi Tshawe to access the funds needed for expanding operations, enhancing service delivery, and investing in new technologies.

Eugene highlighted that “Just a few weeks ago, I was looking at an opportunity posted by TIA to actually encourage companies that are within the clean tech space to apply for funding. Those opportunities are there, also I think Ned bank do have some funding opportunities.”

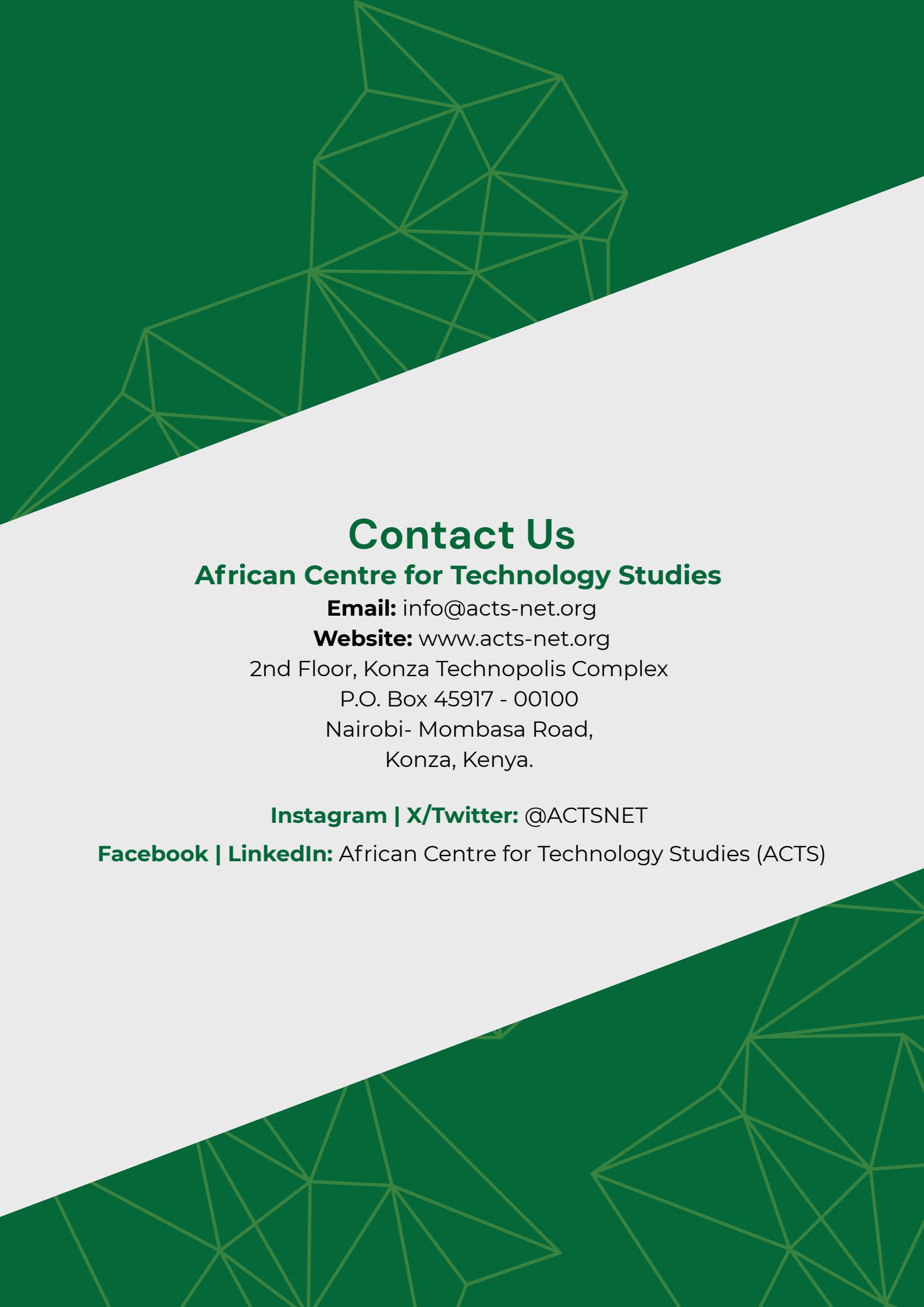
Beyond financial support, such opportunities also offer the potential for partnerships, capacity building, and market linkages, all of which are essential for the cooperative to transition from small-scale operations to a sustainable, high-impact enterprise. By proactively exploring these funding avenues, Tshilidzi Tshawe is well-positioned to leverage external support and scale its contributions to renewable energy adoption and climate change mitigation.

Conclusion

Tshilidzi Tshawe Cooperative case study offers valuable insights into the realities and potential of youth-led CEEs operating in South Africa’s rural contexts. Rooted in agriculture and committed to sustainability, the cooperative has successfully integrated biogas technology into its operations through maintenance services, community education, and the use of bioslurry for farming. Despite their dedication, the cooperative faces several systemic challenges, including limited market awareness, misconceptions about biogas viability, constrained access to capital, and climate-related operational disruptions.

Nonetheless, the cooperative has demonstrated resilience and adaptability, leveraging capacity-building programmes such as those led by Prof. Tinarwo to strengthen technical, business, and soft skills essential for growth. Their inclusive gender dynamics further reflect a progressive approach that values participation and leadership from both men and women. Importantly, emerging funding opportunities from institutions like the TIA and NetBank present promising avenues for scaling their clean energy activities and deepening community impact.

In alignment with the objectives of the EVI-SICEE project, Tshilidzi Tshawe’s experience underscores the critical need for integrated support systems combining financing, technical training, market development, and policy alignment to enable youth- and women-led CEEs to scale and optimize their operations. With continued investment and collaboration, enterprises like Tshilidzi Tshawe Cooperative can play a transformative role in advancing clean energy access, promoting economic inclusion, and contributing to climate resilience across the region.



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