Integrated Investment Strategy for biogas projects in South Africa

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List of abbreviations and acronyms

AD	Anaerobic digestion
CAPEX	Capital expenditure
CHP	Combined heat and power
CNG	Compressed natural gas
CoGTA	Department of Cooperative Governance and Traditional Affairs
DALRRD	Department of Agriculture, Land Reform and Rural Development
D:E	Debt to equity ratio
DEADP	Department of Environmental Affairs and Development Planning (Western Cape)
DFFE	Department of Forestry, Fisheries and the Environment
DFI	Development Finance Institution
DMRE	Department of Mineral Resources and Energy
DSI	Department of Science and Innovation
dtic	Department of Trade, Industry and Competition
DWS	Department of Water and Sanitation
DSCR	Debt service cover ratio
DiBiCoo	Digital Global Biogas Cooperation
FIT	Feed-in-tariff
GHG	Greenhouse gas
GW	gigawatt
IRENA	International Renewable Energy Agency
IRR	Internal rate of return
kW	kilowatt
MSW	Municipal solid waste
MW	megawatt
NERSA	National Energy Regulator of South Africa
OPEX	Operational expenditure
PES.	Payment for ecosystem services
PR	Performance ratio
PV	(Solar) photovoltaic
SABIA	South African Biogas Industry Association
SADC	South African Development Community
SALGA	South African Local Government Association
SPV	Special purpose vehicle
SSEG	Small-scale embedded generation
UNIDO	United Nations Industrial Development Organisation
WC	Western Cape
WtE	Waste-to-energy
WT4E	Waste Transformation 4 Energy Association
WWTW	Wastewater treatment works
ZAR	South African Rand

Executive summary

Globally there have been three main drivers for the development of biogas industries: 1) greenhouse gas emission reduction, 2) waste management and pollution reduction, and 3) renewable energy generation.

In developing an integrated investment strategy for industrial-scale biogas projects within South Africa, this report considers these drivers in the local context and sets out options, combinations of options, and motivations, best suited to the nascent South African biogas business case and market.

This report only explores commercially viable options for biogas. It does not consider projects that would require a significant grant or philanthropic investments (i.e. use of micro-scale biogas in indigent communities). The focus is on the South African biogas market opportunity, although the learnings can be applied to other regional markets.

Determining the potential market size for biogas in South Africa has been challenging. The South African Biogas Industry Association (SABIA) has mapped approximately 36 projects, and from this, they estimate significant potential, if there are additional payments for ecosystem services (PES), in the short term.

Various projects implemented in South Africa demonstrate that a combination of waste management and electricity sales have been used successfully to build the biogas business case. The waste management component of these projects has been a key lever for success. Many of the projects that focused solely on electricity have either failed or have been delayed.

Positioning biogas projects as primarily waste management projects (in contrast with being positioned primarily as an option for electricity generation), has been a useful approach in South Africa. When this positioning was tested with the finance providers involved in this project, they indicated that this category of projects is well understood.

A set of final recommendations to enable investment in biogas projects include 1) support for early-stage project development as well as 2) encouraging biogas project developers to think about, and design, projects as waste management projects, building the investment case on revenue from gate fees or payment for waste management services, rather than relying on (stacking of) other revenue streams (i.e. electricity sales). This will allow projects to be sized correctly (based on the available waste stream that needs to be managed) and enhance the probability of receiving investment in the South African case.

A central fund and support structure is recommended to address current gaps in the market. This central funding mechanism would need to be supported by grant or concessionary finance, it could be managed by the industry associations, such as SABIA and WT4E[1]. Such a fund could provide support for pre-feasibility assessments, specialised project preparation services and project pooling, increasing the probability of the project being successfully built.

Additional insights include that the continued legal requirements and associated pressures with regard to landfill disposal are expected to enhance the value proposition for biogas as a waste management solution in the medium to long term.

[1] Waste Transformation 4 Energy (WT4E) Association is the umbrella association for waste-to-energy (WtE) project developers, technologies suppliers, financiers and operators in Africa. Website: https://wt4e.com/

1. Background and context

1.1. Global context

The production of biogas has considerable environmental benefits. **The three main drivers of environmental benefits from biogas are:**

- Greenhouse gas reduction - Biogas production helps reduce greenhouse gas (GHG) emissions by capturing and utilising methane. Methane is produced during the decomposition of organic waste in landfills, wastewater treatment works and agricultural activities. Through capturing and utilising this methane, these emissions are avoided[2].
- Waste management and pollution reduction - Biogas production helps address waste management challenges by utilising organic waste streams, such as agricultural residues, food waste, and sewage sludge. Diverting organic waste from landfills reduces methane emissions, odour, and potential groundwater contamination. Biogas plants also help in controlling water pollution by treating and utilising wastewater from various sources.
- Renewable energy generation - Biogas is a renewable energy source that can replace fossil fuels in various applications. It can be used for electricity and heat production, replacing coal or natural gas in power plants and heating systems. Biogas can also be upgraded to biomethane, which has similar properties to natural gas and can be injected into the natural gas grid or used as a transportation fuel, replacing diesel or petrol. This reduces dependence on finite fossil fuel resources and contributes to the transition toward a more sustainable energy system.

The business case for biogas varies internationally:

- Germany[3] is widely recognised as a global leader in biogas to energy generation project development. It has a well-established biogas sector with a significant number of biogas plants in operation. The German market's success can be attributed to a combination of factors, including a strong regulatory framework, generous feed-in-tariffs (FITs), guaranteed grid access, and favourable financing options. The Country's Renewable Energy Sources Act (EEG[4]) has played a crucial role in supporting biogas development by providing stable and long-term incentives for renewable energy generation.
- Denmark[5] and Sweden[6] also have substantial biogas sectors. These countries have implemented supportive policies and regulations, such as feed-in tariffs, tax incentives, and favourable waste management regulations. Additionally, these countries have focused on utilising organic waste streams, agricultural residues, and energy crops to produce biogas, thereby addressing waste management challenges and promoting sustainable agriculture.

[2] Although biogas combustion emits carbon dioxide (CO_2), the relative impact in terms of contributing to climate change is considerably less.
[3] Synthesis from Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz: EEG) - https://www.bmwi.de/Redaktion/EN/Artikel/Energy/renewable-energy-sources-act.html & German Biogas Association (Fachverband Biogas e.V.) - https://www.biogas.org/
[4] EEG = Erneuerbare-Energien-Gesetz
[5] Danish Energy Agency: Biogas - https://ens.dk/en/our-services/renewable-energy/biogas & Danish Biogas Association (Biogasbranchen) - https://biogasbranchen.dk/en/
[6] Swedish Energy Agency: Biogas - https://www.energimyndigheten.se/en/sustainability/bioenergy/biogas/ & Swedish Gas Association: Biogas - https://www.svenskgas.se/en/sustainable-gas/biogas/

- In the United States[7], the development of biogas has been driven by a combination of federal and state-level policies, financial incentives, and renewable energy targets. The federal Renewable Fuel Standard (RFS) program and tax credits such as the Investment Tax Credit (ITC) and Production Tax Credit (PTC) have provided support for biogas projects. State-level renewable portfolio standards, net metering policies, and grants or loans from government programs and utilities have also contributed to the growth of the biogas industry.

The commonality amongst all of these markets is that there was a direct market intervention required to support the development of these markets. In the European Union (EU), one of the large elements of this case is electricity sales and the enabling environment for electricity sales (e.g., grid access, etc.). Several other examples (tax credits, production credits) and the waste management challenge has also formed economic and financial foundations for projects.

1.2. South African context and the motivation for the development of an investment strategy

The South African biogas sector is nascent. Increased uptake of biogas technologies and development of local expertise would assist the industry in maturing to a commercially sustainable level.[8]

The drivers that have supported the maturation of global biogas industries are not fully present in South Africa, but there are several enablers for the industry. However, complexity abounds for projects as they investigate value propositions for biogas in the South African context. The Global Environment Facility (GEF)-funded Project, through the implementing agent – UNIDO and key stakeholders, initiated the development of a report to inform the integrated investment strategy for industrial-scale biogas projects within South Africa. The project intended to highlight the industry as a positive investment possibility for financiers.

1.3. Project approach and scope

In-depth qualitative interviews were held with financiers between May and June 2022. The discussions included funders and financiers who had financed biogas projects (both ongoing successful projects, and unsuccessful projects); financiers considering financing the industry, as well as green finance entities involved in other segments of the green economy. These entities included commercial banks, institutional investors, private equity firms, corporate funders, asset managers, venture capitalists, impact funds, angel investors, government-backed funds, climate funds, bilateral development partners and development finance institutions.

The predominant mechanisms of funding employed and discussed were debt, equity, mezzanine finance, quasi-equity, de-risking products, concessional finance, guarantees, project finance and grant funding. The insights garnered from these in-depth engagements, along with historical and ongoing engagements with industry stakeholders, provided insights into the framework for the biogas investment strategy.

Given that the main drivers of environmental and commercial cases differ, the approach taken was to identify opportunities to enhance the biogas industry's deployment of projects by emphasising where the commercial cases are the strongest for the existing pools of capital available for projects.

[7] U.S. Environmental Protection Agency (EPA): Biogas - https://www.epa.gov/agstar/biogas-systems & American Biogas Council - https://americanbiogascouncil.org/

[8] Based on detailed engagements held by GreenCape through the Digital Global Biogas Cooperation (DiBiCoo): https://dibicoo.org/

2. Investment Plan and Financing Mechanism for Biogas Development

The South African biogas sector is considered to be in the infancy stage, with a fairly small cohort of project developers and a relatively small number of projects. The South African Biogas Industry Association (SABIA) has mapped approximately 36 projects and estimates significant potential if there are additional payments for ecosystem services (PES). Should the fundamental market structure shift to accommodate these projects, SABIA estimated that the biogas market will have a ZAR value of approximately between ZAR 52 billion and ZAR 250 billion.

The drivers that have supported the maturation of global biogas industries are not fully present in South Africa, but there are still several enablers for the industry. There are examples of projects[9] that have been built in South Africa, demonstrating that a combination of waste management and electricity sales have been used successfully to build the biogas business case.

Through in-depth stakeholder engagement, it has, however, become clear that the waste management component of these projects is a key lever for success. Packaging biogas projects as waste management projects has proven to be a good approach in South Africa and when this was tested with the financiers consulted during the drafting of this report, they indicated that waste management projects as a category are well understood by the South African finance community from a risk and rewards perspective.

2.1. Recommended investment strategy for the biogas industry

Given that the main drivers of environmental and commercial cases differ; the recommendation is for an investment strategy that emphasises where the **commercial** cases are the strongest for the existing pools of capital available for projects. Biogas projects are relatively new projects for South African financiers. However, waste management, waste handling and waste processing are not new categories and could provide a familiar context for investment decision-making.

By designing and communicating biogas projects as waste management projects, the ability of financiers to identify and quantify the key risks improves. Stacking multiple revenue streams on top of each other adds significant complexity, and the framing of these projects as electricity generation projects meant that the information required by the finance community to compare biogas with other energy generation technologies created a bottleneck.

Recommendations:

- The biogas industry should focus on attracting investments positioned on the business case for waste management, building the return-on-investment case on revenue from gate fees or payment for waste management services rather than relying on (stacking of) other revenue streams (i.e. electricity sales).
- Locating facilities to minimise logistics cost is often a key requirement for successful projects. Projects, where there are opportunities to co-locate for waste management, biogas and digestate offtake, are more likely to succeed.

[9] https://green-cape.co.za/assets/Uploads/GreenCape-Biogas-Business-Case-Final.pdf

2.2. Proposed funding mechanism to support the biogas industry

There is a considerable amount of finance available for green economy and green energy projects. However, there is a shortage of support for project initiation, preparation and feasibility early in the project cycle. This is where additional investments are required to strengthen the biogas market.

A supportive ecosystem for knowledge sharing could be used to address part of the current gap in the market. Developers would benefit from technical and business mentorship support. Financiers would benefit from understanding from neutral third parties how to assess and think through these projects.

A central, direct, funding mechanism, which could be managed by the industry associations, such as SABIA and WT4E[10], could potentially provide the following specific support services:

- Pre-feasibility assessment
- Specialised project preparation
- Project pooling

The combination of these three services would create a pipeline of investment-ready projects that could be pooled into larger portfolios to attract the needed commercial finance.

2.2.1. Pre-feasibility assessment

The first step in building a proposed funding mechanism to support the biogas industry is building a pipeline of investment-ready projects that can attract commercial finance. Table 1 provides a breakdown of the assessment aspect of the proposed funding mechanism. The ability to show a pipeline of projects that have already been vetted by a trusted entity can decrease the time and money spent by investors on screening and conducting pre-diligence to find the investments that fit their mandate.

Table 1: Intervention 1: Support at the 'Pre-feasibility' stage

Area of work	Detail
Challenges	• Local and international investors are generally presented with a high volume of projects, but the total number of investments is low. This points to the quality of projects being presented being low, or not meeting the expectation of the investors. • A large proportion of time is spent screening and conducting pre-diligence to find the investments which fit the mandates of the investors, particularly in sectors or territories they are unfamiliar with or not physically in (i.e. waste management vs electricity, as discussed above).
Market response	• The market has been typically ad hoc in presenting and pursuing projects – this has had some limited success, but has a high transition cost.
Key steps/considerations in informing the pre-feasibility aspects	An independent, neutral expert on biogas that will provide support in assessing requirements for bankable, investment-ready projects by scrutinising the key risk drivers associated with biogas: • feedstock availability and quality; • developer track record and experience; • technology risk; • policy and regulatory framework particular to the geographic region; • project size.
Outcome/Output	• Many projects will get to a negative answer faster, preserving resources for a higher likelihood of successful projects. • Local and international investors will see higher quality projects more tailored to their needs. • An improved pipeline of investment-ready biogas projects focused on waste management opportunities.

[10] Waste Transformation 4 Energy (WT4E) Association is the umbrella association for waste-to-energy (WtE) project developers, technologies suppliers, financiers and operators in Africa. Website: https://wt4e.com/

2.2.2. Specialised project preparation

The second step in building a proposed funding mechanism is the provision of grant-funded technical assistance in the project preparation phase. The South African biogas sector is considered to be in the infancy stage, with a fairly small cohort of project developers and a relatively small number of projects. Table 2 provides a breakdown of the specialised project preparation aspect of the proposed funding mechanism.

Table 2: Intervention 2: Specialised project preparation interventions

Area of work	Detail
Project preparation stage	Projects do not typically have a significant level of resources to work toward project preparation. This can lead to lower-quality projects being developed.
Market response	• Projects are bootstrapping their project development based on the experience of their team.
Intervention (Support for developers via the industry association)	• Specialised project preparation incubators would assist biogas project developers with project preparation. • Fund and support projects to move from feasibility to bankability (specialist technical studies) • Address quality control concerns and risk mitigation.
Impact	• Present local and international investors with higher quality investment opportunities and support investment facilitation and reduce investment due-diligence needs. • An improved pipeline of investment-ready biogas projects focused on waste management opportunities.

Technical assistance support has the potential to grow the impact of the biogas sector in South Africa, present local and international investors higher quality investment opportunities, facilitate investment and reduce investment due diligence needs.

2.2.3. Project pooling

The third step in building a proposed funding mechanism is creating the mechanism to allow the pooling of similar projects into investment "baskets" to attract investors with larger ticket sizes. Based on the assessment of current projects, the viability of future projects (see Table 4) and the available finance, a facility is needed that looks to pool investable biogas projects into larger portfolios to facilitate investments. Table 3 below provides details of the project pooling intervention that would support reducing transaction costs associated with investing in smaller projects.

Table 3: Intervention 3: Project pooling intervention

Area of work	Detail
Market failure or gap	• Smaller projects are not big enough to attract investment. • High variability between projects, resulting in relatively high per-project transaction costs.
Market response	• Projects continue to fundraise on an individual basis.
Intervention	• The pooling of smaller, investable biogas projects assists financiers in mitigating risk across multiple entities and addresses fixed internal transaction costs with the benefit of economies-of-scale savings on smaller projects. • Pooled projects could be repeatable with similar design and technology, thus saving construction time with the potential of lower costs for materials.
Impact	• Present local and international investors with higher quality investment opportunities and support investment facilitation and reduce investment due-diligence needs. • The improved pipeline of investment-ready biogas projects focused on waste management • Reduced cost of capital for pooled projects.

To unleash the potential of the biogas market there are a handful of interventions that have been identified. Primarily the design, fundraising and communication of biogas projects as waste projects. Then support the developers in running their own businesses and technical support for projects. Finally, mechanisms could pool or aggregate projects to improve the per-project transaction costs.

3. Overview of the status of SA's biogas industry

South Africa's small biogas market has projects that are underpinned by unique circumstances. This is typical of a new sector or technology being adopted in a nascent market. This does, however, provide some challenges in communicating the potential market size, market access/appetite and key drivers. As indicated in section 1.1, international biogas markets have been driven by a combination of incentives and drivers in key markets (e.g. feed-in tariffs). The challenges in communicating the main financial drivers in different markets, when those same fundamentals do not exist in South Africa, are acutely felt by financiers and capital providers. This uncertainty results in a wide variety of estimates of the market potential for biogas.

3.1. Perceived market potential

SABIA published a market position paper in 2021 that highlighted the market (Table 4) and the potential of biogas, across several key focus areas. This position paper sets out the biogas potential, should several key enablers be unlocked (in particular a PES). Given that there is currently no planned PES for biogas, and the market potential depends on a PES, this is likely overstated as this is several orders of magnitude larger than the current market. However, it is a useful starting point to unpack the expectations, market size and opportunity for the biogas sector in South Africa, as well as a clear demonstration of where SABIA, as the Industry Association, believed the opportunity lay in 2020 and how to construct an investment case within the South African context.

SABIA has estimated the biogas market to have a ZAR value between ZAR 52 billion and ZAR 250 billion. Investment may be unlocked should the fundamental market structure shift to accommodate these projects. In Table 4 below SABIA has estimated the South African Biogas market potential as an energy provision technology.

Table 4: South African Biogas market potential as an energy provision technology[11]

Industry /Sector generation potential	Theoretical (MW)	Feasible within 5 years from 2021 (MW)
Agricultural sector	1179	103
Dairy sector	597	299
Piggery sector	107	53
Chicken sector	4777	478
Wastewater treatment sector	210	93
Municipal solid waste	2028	101
Sugarcane	1024	53
Food processing abattoir	175	18
Landfill	200	57
Biogas's Potential for power generation	10 297	1254
Total market growth based on 30MW baseline	10 267	1224
Average project installed size (MW)	0.5	0.5

The market potential presented above focuses on sectors where the commercial cases are the strongest. The industry association estimates that by 2026 it is feasible for the current installed capacity of 30MWs to grow to +-1254MWs. This growth will largely be driven by sectors that have waste products that can be processed on-site (i.e. dairy and chicken sector). This supports the argument for a waste-focused value-addition narrative for the sector as presented in this report.

[11] South African Biogas Industry Association (SABIA) (2021). *Market Position Paper*.

3.2. Existing market

The projects mapped on the SABIA website[12] (at the time of drafting - May 2023) reflect the projects and categories summarised in Table 5. These are projects that have been recognised by the leading industry body for biogas provide a highly relevant categorisation of what has been achieved and where, and provide some insight into the drivers of those projects. The mapping shows a focus on larger-scale commercially viable projects located on a site where there is waste steam that must be treated or transported off-site at an additional cost.

Table 5: Biogas projects mapped on South African Biogas Association (SABIA) website May 2023

Category	Number of projects
Industrial-scale anaerobic digestion	31
Landfill gas power generation plant	4
Micro-scale anaerobic digestion	1

The categorisation of the successful projects in South Africa supports the argument for a waste-focused value-addition narrative for the sector as presented in this report. This is further supported by the data presented in Table 6 which sets out the main drivers of biogas projects in South Africa.

The assessment of the drivers is based on the GreenCape teams' engagement with the biogas industry and the financiers over several years. The relevance of the drivers is rated as follows:

- **Low**: Projects typically do not use this as a motivating factor
- **Medium**: some projects use this as a motivating factor
- **High**: projects use this as a motivating factor).

Table 6: Drivers of different types of projects in South Africa

Project archetype	Greenhouse gas (GHG) case	Waste management case	Electricity tariff case	Notes
Industrial-scale anaerobic digestion	Low	High	Low/Medium	This scale is the most common and the combination of waste and electricity drivers is the most common case.
Landfill gas power generation plant	Medium	Medium	Medium/High	There are a few landfill gas projects, with a fairly varied set of drivers.
Micro-scale anaerobic digestion[13]	Medium	Low	Low	Typically driven by co-benefits.

[12] See in particular: https://sabia.org.za/biogas-map

[13] It is worth addressing micro scale anaerobic digestion (AD). There are numerous examples of micro scale AD plants delivered by researchers, philanthropic institution, municipalities looking for alternative organic treatment – these cases are all financed via non-commercial investment cases. In other words, there are co-benefits to the finance providers that form the basis for the justification for these projects. This is a very interesting case as there are clear markets. The focus of this investment report is to search for repeatable commercial cases which will allow the industry to grow and attract private, commercial capital.

Table 6 shows that within the current industrial-scale anaerobic digestion projects in South Africa, waste management is seen as the most relevant driver for a successful business case. It shows that landfill gas has used a mixture of elements and that Micro-Scale Anaerobic digestion has relied on co-benefits rather than primary cases for GHG, Waste management or Electricity sales.

3.3. Conclusion on market sizing

Obtaining an accurate picture of the market size in the South African context is challenging as there are different sets of key drivers relevant to different types and scales of projects.

4. Viable biogas project models and scales

Given the current and potential biogas market, an analysis of current infrastructure and what is needed to strengthen the business case for biogas:

- Industrial-scale anaerobic digestion has the best business case along with large installations on wastewater treatment facilities.
- Locating facilities on-site (waste management and offtake for biogas and digestate) reduces infrastructure costs and improves the prospect of successful projects.
- The business case of viable projects is based on waste management and building the investment case on revenue from gate fees or payment for waste management services rather than relying on (stacking of) other revenue streams (i.e. electricity sales).
- Designing and communicating biogas projects as waste management projects has been a useful approach in South Africa and when this was validated with the financiers, they indicated that the risks and rewards for waste management were well understood.
- There is a considerable amount of finance available for the green economy and specifically green energy projects. However, there is a shortage of financial and technical support early in the project cycle, for project initiation, preparation and feasibility. This is where additional investments are required to strengthen the biogas market.

Table 7 sets out examples of viable project models and their financial structures. These models are based on projects that have been successfully executed in the South African context. This should be viewed in combination with Table 5 and Table 6.

Table 7: Current viable project models for biogas[14]

Size	Small	Medium
Type	Private	Project finance or SPV
ZAR value	*R2m - R20 million	*R20m - R400 million
Typical project size	< 500kW	> 500kW
Key component	**Site/developer collateral	Off-take guarantee (gas and or electricity), Wheeling agreement, Feedstock guarantee/security with alternatives
ZAR/kWh	***R1.4- R1.5/kWh	***R1.4-1.5/kWh; R145-R180/GJ of CNG
Site conditions	Feedstock on-site Offtake on-site Digestate zero cost to the project	The portion of feedstock or offtake on-site Need digestate management process (net zero financial impact)
Site options	Abattoirs, feedlots, chicken farms, malls, piggeries, food processing, fruit and vegetable processing	Mega farm (single supply), centralised farm (multiple feedstock supply)

[14] UNIDO project (ID:130310): *Promoting organic waste-to-energy and other low-carbon technologies in small and medium and micro-scale enterprises (SMMEs): Accelerating biogas market development.*

Size	Small	Medium
Revenue model	Electricity and heat and /or gas and offset disposal fees	Premium on electricity sales[15] (banking on green energy premium or Eskom rising above fixed escalation), Gas sales - CNG projects > 1.5MW, Combination of on-site use, offset disposal fees and heat use
Financing	D:E - 60:40 IRR - 18-25% Debt tenor - 7- 10 years Rate - 10.5- 12% Fund 5 years with options to refinance residual value (Debt requires min tail of 3 years) DSCR - 1.3	D:E - 70:30 IRR - 18-25% Debt tenor - 12 years Debt requires a track record of 3 years DSCR - 1.3, Debt reserve account 6 months (interest and capital)
Cover	Site owner/developer balance sheet strength (different revenue stream options), land collateral	Cession rights, buy-back options Independent assessment for feedstock/design PR guarantees plant Continuous feedstock analysis (visual or test) Insurance options
Key considerations	No revenue was considered during the first 6-12 month post commissioning	No revenue considered during 6 - 12 month post commissioning 50% buffer on feedstock supply At least 1 main feedstock supplier with 2 secondary options
***An indicative CAPEX cost for a biogas plant is R40 million/MW provided by industry experts in 2017. ****How a developer would finance a biogas plant would be through their balance sheet or an offtake agreement with the site owner. This could be included as developer collateral. *****An indicative value provided by industry experts. **NOTE:** A project can still be financially viable if a value above or below is quoted, but it requires a justification for the value quoted.		

Acronyms: D:E – debt to equity ratio, IRR – internal rate of return, DSCR – debt service cover ratio, PR – performance ratio, SPV = special purpose vehicle, CNG = compressed natural gas

Several insights can be extracted from this Table 7:

- Waste management was considered as feedstock security – the projects are co-located with the feedstock provider.
- Electricity sales were a part of the business case (either consumption on-site or through a combination of consumption and wheeling).
- Additional revenue streams (digestate, heat, etc.) were sought to enhance the case.
- Project structures might be limiting. (Project finance structures are typically complex and costly to set up and relying on the site owner/client's balance sheet will limit the number of projects that can move forward).

15 This might not be systematically repeatable as the cost of Renewable energy, particularly rooftop PV has fallen.

5. Policy and regulatory environment

5.1. Overview of policy and regulatory landscape

The South African policy and regulatory landscape has evolved over the last decade. On a project-by-project basis, there are a number of regulations that are relevant in the planning and execution of a successful project. Figure 1 summarises the legislation that applies to biogas projects.

Figure 1: Overview of legislation, regulation and policy that need to be considered for biogas projects[16]

From Figure 1 it is clear that the legislation, regulation and policy that need to be considered for biogas projects is extensive and can create increased market latency.

[16] GreenCape (2022). *Municipal Brief: The opportunity for waste-to-energy in Cape Town and the Western Cape.* https://green-cape.co.za/assets/WtE_INDUSTRY_BRIEF_e3-WEB.pdf

As part of the National Biogas Platform[17], a series of flow charts to help navigate the relevant licensing and permitting procedures for biogas, landfill gas and biomass were developed and published in 2014. In 2015, an online guide to the policy landscape and municipal legislative requirements for alternative waste management technologies was launched on the website of the then Department of Environmental Affairs (now the Department of Forestry, Fisheries and the Environment (DFFE))[18] and, more recently, a summary of regulations for consideration when implementing biogas projects have been included in the DFFE's 2021 Biogas Handbook.[19] There are also several other useful resources on the legislative environment available including as part of GreenCape's market intelligence reports[20], and on the website of SABIA.[21]

5.2. Conclusion on policy and regulatory environment

Despite the availability of (largely dated) guides and summaries of the policy and regulatory environment, there is a need and opportunity for the biogas industry association to provide further support in navigating the complexity of the regulations as these do add a significant barrier to entry for new developers, as well as a level of complexity for financiers in the legal reviews required to execute projects.

As such, simplifying the requirements, advocacy and outreach for biogas to energy generation initiatives, given the environmental benefits, renewable energy generation potential and greenhouse gas emission reductions, must be motivated, on an ongoing basis.

[17] National Biogas Platform: https://www.energy.gov.za/files/biogas/nationalBiogasPlatform.html
[18] Alternative Waste Treatment Guide: http://awtguide.environment.gov.za/
[19] Department of Forestry, Fisheries and the Environment (DFFE) (2021), *Biogas Guidebook for Small- to Medium-Scale Industrial Biogas Plants in South Africa.*
https://www.dffe.gov.za/sites/default/files/docs/biogasguideook_industrialplants.pdf
[20] GreenCape market intelligence reports: https://green-cape.co.za/market-intelligence/
[21] South African National Biogas Association (SABIA) website: https://sabia.org.za/)

6. Availability of finance

6.1. Funders consulted

Table 8 provides a summary of the types of funders and specific institutions consulted to obtain insight into the funding landscape for biogas projects.

With the primary focus of this report being the strategy needed to unlock investment into the biogas sector, the insights from these stakeholders were key to the proposed strategy.

Table 8: Funders consulted

#	Institution type	Specific Institutions
1	Retail Bank	Standard Bank
2	Retail Bank	FNB
3	Retail Bank	Nedbank
4	Private Equity	AIIM Africa
5	Private Equity	Inspired Evolution
6	Private Equity	Metier
7	Private Equity	Pegasys Capital
8	Private Equity	Savant
9	NDFI	DBSA
10	Multilateral public-private partnership	PFAN
11	MDFI	Norfund
12	Investment fund managers	First Fund
13	Investment fund managers	Infra Impact
14	Investment fund managers	Investec
15	Investment fund managers	Mergence
16	Investment fund managers	Mergence
17	Investment fund managers	Moshesh
18	Fund Managers	Edge Growth
19	DFI	AFDB
20	DFI	BII
21	DFI	Green-Create
22	DFI	IFC
23	DFI	US Plus

The fundamental insight from the consulted finance stakeholders is that there is a lot of finance available for projects that meet the needs of the financers interviewed. However, there are not many projects that are meeting the needs of the financers. And, in particular, there are significant gaps in finance for the project pipeline building, preparation and feasibility to get cohorts of projects to be able to access the available capital.

6.2. Project life cycle

Figure 2 sets out a typical biogas project development cycle. Consultation with funders concerning this typical cycle is a useful mechanism to identify where there are potential funders and funding availability and where there are gaps.

The key insight from the system of information gathered concerning the project life cycle (Figure 2) is that there is very limited funding available for project initiation and project development. This is a common challenge in new or emerging sectors where technical and implementation risk remains high. This gap is traditionally filled by grant funders or technical assistance funds.

This is extremely relevant as a potential area for intervention for the industry association and development finance institutions (DFIs) – if there is little or no finance for building project pipelines, there will be very few projects that are available to be financed.

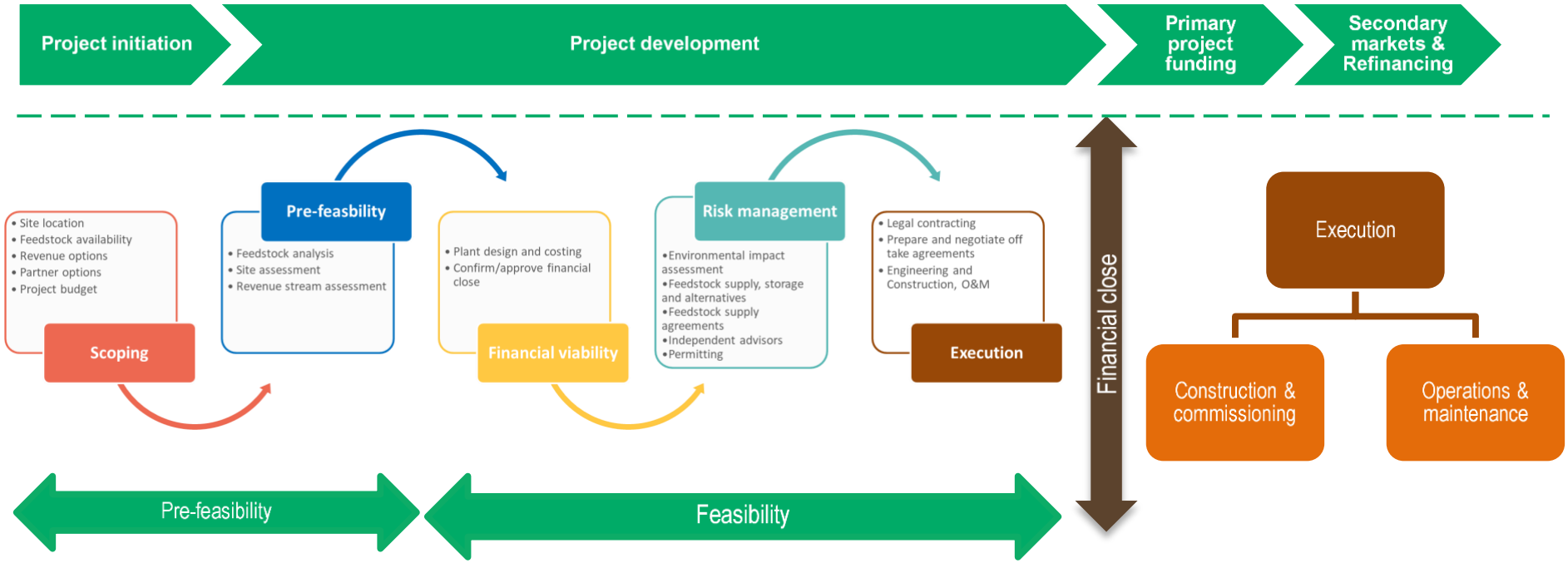

Figure 2: Biogas project development life cycle

The tables that follow set out where there is existing active and involved finance provision for biogas projects. **Table** 9 provides a breakdown of the funding mechanisms available from the funders as detailed in Table 8. This information was gathered from financiers and is considered publicly available information.

Table 9: funding mechanisms and project stages

Company name	Mechanism(s) of funding available:							The stage(s) at v
	Debt	Equity	Grant	Mezzanine	Project	De-Risking	Concessional	Project Initiation
Standard Bank	✓	✓						
Nedbank	✓	✓						
Infra Impact		✓			✓			
Savant	✓	✓			✓			
Development Bank of South Africa (DBSA)	✓	✓						✓
Norfund	✓	✓						
Metier	✓	✓		✓				
Moshesh	✓	✓		✓	✓			
PFAN	✓	✓	✓	✓				
BII	✓					✓		✓
CDI Capital			✓					✓
Edge Growth	✓	✓		✓		✓	✓	
RMB // First Fund	✓							
Revego Africa Energy	✓	✓						
Pegasys Capital Partners	✓	✓		✓				
AIIM		✓						

Table 9 sets out a range of funders and funding types. As discussed there are limited options for project initiation and project development. The majority of finance is available as commercial debt or equity with a focus on primary project finance. Primary project finance is the financing of long-term infrastructure and industrial projects using a non- or limited-recourse financial structure. Given the nascent nature of the sector refinancing relevance is limited but this will change as projects mature. Table 16 in


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Annexure A: Funding mechanisms reviewed relevant to biogas provides a summary of the types of funders and specific institutions reviewed to obtain insight into the funding landscape for biogas projects. More detail is provided in the Excel database.

The database contains information on funding opportunities, the types of funding tools and institutions providing the funding, and contact details which are publicly available. This includes information on national market players (e.g. commercial banks, microfinance banks, private equity/debt, venture capital/angel investors etc.), as well as international climate finance streams (e.g. climate funds, development finance institutions, multilateral institutions, bilateral development partners and domestic sources of finance. The database analysed ~125 financing solutions valued at ~ZAR 25 billion. The database is ideal for a biogas entity seeking a broad range of funding solutions and financial incentives, with a largely South African focus.

Building on the data provided above, Table 10 indicates the types of institutions which may be relevant in funding, specific segments of the project development cycle. Table 10 also indicates whether or not an institution is active in that specific segment of the project development cycle.

Table 10: Types of institutions for finance for the South African biogas industry

Types of institutions	Project initiation	Project development	Project funding	Refinancing
Commercial bank	Not relevant	Significant gap	Partially available	Significant gap
Institutional investor	Not relevant	Not relevant	Partially available	Partially available
Private Equity	Significant gap	Partially available	Available	Available
Corporate funder	Partially available	Partially available	Partially available	Partially available
Asset manager	Not relevant	Not relevant	Partially available	Partially available
Venture capital	Significant gap	Significant gap	Not relevant	Not relevant
Impact fund	Significant gap	Significant gap	Partially available	Not relevant
Angel investor	Significant gap	Significant gap	Not relevant	Not relevant
Government budget	Gap	Gap	Partially available	Not relevant
Climate fund	Significant gap	Partially available	Partially available	Not relevant
Bilateral development partner	Partially available	Partially available	Available	Not relevant
Development finance institution	Partially available	Partially available	Available	Not relevant

The following legend applies to the tables below:

Not relevant	Source / Instrument not relevant at this stage of project financing in South Africa
Available	Investors and/or instruments are relevant and currently **fully active & involved** in that specific segment in South Africa
Partially available	Investors and/or instruments are relevant and **partially active & involved** in that specific segment in South Africa
Gap	Investors and/or instruments **are relevant** in that specific segment in South Africa
Significant gap	Investors and/or instruments are relevant but **not active & involved** in that specific segment in South Africa

From Table 10 it is apparent that there are significant gaps where investors are relevant but not active or involved in that specific segment. This could be useful places for the Industry association and/or Government and its partners to intervene to build capacity in the finance community in understanding biogas projects, more comprehensively.

Several key products can to offered for biogas projects. Some of these products will only be relevant at specific portions of the project life cycle. Table 11 shows the key financial instruments available for biogas project development.

Table 11: Key financial products/instruments for biogas project development.

Instrument	Project initiation	Project development	Project funding	Refinancing
Company balance sheet	Partially available	Partially available	Partially available	Partially available
Corporate bank loan	Not relevant	Not relevant	Partially available	Partially available
Project Finance	Not relevant	Not relevant	Available	Available
Structured finance	Not relevant	Not relevant	Partially available	Partially available
Bond	Not relevant	Not relevant	Partially available	Partially available
Green/blue/social/sustainable bond	Not relevant	Partially available	Significant gap	Significant gap
De-risking product	Not relevant	Not relevant	Partially available	Partially available
Concessional finance	Gap	Partially available	Partially available	Not relevant
Grant	Gap	Partially available	Significant gap	Not relevant
Government budget spend	Significant gap	Partially available	Partially available	Not relevant

As can be seen from Table 11, the key gaps for the industry association and Government to respond to are in the project initiation - grants and concessional finance, in particular.

Table 12 below indicates that there is over **USD 6 bn+** of funds available in green finance. There is thus a really large amount of money with funders that have a mandate and a desire to fund/finance green projects that fit within their respective mandates. These could be utilised toward biogas projects.

Table 12: Finance sample of green finance capital available

Institution (sample size)	Available fund size estimate (R)	The stage(s) at which financing is available:				Business development support
		Project initiation	Project development	Primary project funding	Secondary markets and refinancing	
Retail Banks (5)	-	Significant gap	Partially available	Available	Available	Significant gap
Investment fund managers (5)	*R17.20B+	Gap	Partially available	Available	Gap	Partially available
Private Equity (4)	R24.61B+	Significant gap	Available	Available	Gap	Partially available
NDFI (1)	R2.56B+	Significant gap	Available	Available	Significant gap	Significant gap
Bilateral DFI (1)	R3.28B+	Significant gap	Significant gap	Available	Available	Gap
DFI (1)	*R49.32B+	Gap	Significant gap	Available	Significant gap	Significant gap
Multilateral public-private partnership (1)	R1.64B+	Significant gap	Available	Available	Significant gap	Available
Capital Fund Managers (1)	*R0.005B+	Available	Available	Significant gap	Significant gap	Partially available
Total (16)	***R98.62B+ USD6B+**	**Significant gap**	**Partially available**	**Available**	**Partially available**	**Gap**

* Indicates that a portion of the funding is available over the next 5 years

6.3. Conclusion on the availability of finance

The tables above show an impressive collection of finance available for projects like biogas. The fundamental insight is that there is a lot of finance available for projects that meet the needs of the financers interviewed.

However, there are not many projects that are meeting the needs of the financers. And, in particular, there are significant gaps in finance for the project pipeline building, preparation and feasibility to get cohorts of projects to be able to access the available capital.

7. Insights from financial investors

7.1. Main insight

Biogas projects are relatively new projects for South African financiers. However, waste management, waste handling and waste processing are not new. By building and packaging biogas projects as waste management projects[22], the ability to identify and quantify the key risks improves. Stacking multiple revenue streams on top of each other adds significant complexity, and the framing of these projects as electricity generation projects meant that the comparison and information being sought by the finance community to compare with other energy generation technologies created a bottleneck. The main insight is to place waste management as the core driver of a biogas project.

7.2. Other insights

The key risks that the finance community will look to in the assessment of projects are summarised in Figure 3 and unpacked in further detail below.

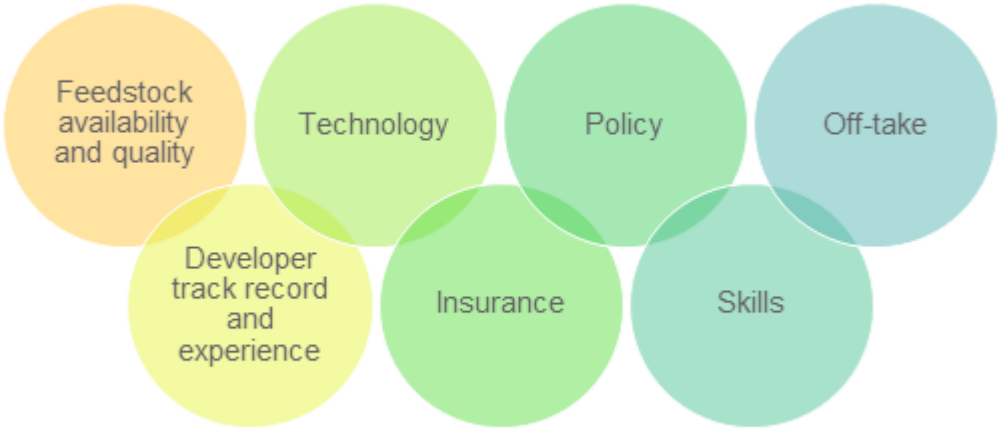


Figure 3: Key risks associated with biogas project considered by financiers

- **Feedstock availability, quality, quantity and composition:** Biogas projects are typically built on the sustainability of feedstock supply. Securing quality feedstock material with consistent, predictable availability and composition is critical to the success of the project. When developed as a waste management project, the emphasis is on the duration of the agreement for treating the waste feedstock.
- **Developer track record and experience**: As with any credit risk, financial investors prefer projects prepared by reputable developers with existing knowledge and experience. These factors likely impact the success of a project.
- **Technology risk:** Although biogas technologies are technically mature and proven, they are not regarded as financially mature technologies, i.e. whether these technologies can perform reliably within the set project conditions that allow for a financially viable and bankable business case.
- **Insurance**: Insurance affordability for biogas projects tends to be costly due to the associated risks of biogas being assessed as natural gas (methane) and the historical success of projects in South Africa.

[22] The term waste management is used here to refer to both solid waste management and waste water treatment.

- **Policy changes and landscape:** Enforcement of policies and regulations by the government can create a stable, known environment. Policy inconsistencies result in a cost and risk factor for doing business in South Africa and the SADC region.
- **Skills availability:** Due to the nascent nature of the biogas industries in South Africa, there are limited operations and process controllers for biogas projects. As a result, the skills required are often scarce or filled by inexperienced highly educated graduates that may be more expensive than budgeted for.
- **Off-take agreements:** Securing long-term sustainable off-take agreements to support the investment into the future. Off-take infrastructure also poses a risk in that the lack of gas grids necessitates the installation of more expensive bottling plants. However, when developing a project as a waste management project and not relying on stacking revenue streams, this aspect is of lesser importance.

Other notable discussion points:

- **Project size:** This impacts the size of financing requirements, as well as the number of projects financial investors can finance. The fixed costs associated with financing projects do not necessarily change the internal cost to the company; which may impact the attractiveness of smaller projects.
- **Project initiation and project development funding challenges:** The inception of projects are based on strong balance sheets of project developers/partners.
- **Pure energy provision solution:** biogas projects present poor viable business revenue models as it is not market competitive compared to other renewable energy sources when the business case is built as an energy provision technology only.
- **Waste management and wastewater treatment solution:** biogas projects presented as a waste management and wastewater treatment solution business case, which is in line with emerging policy changes, have been favourably received.
- **Circular economy:** biogas projects that are closed, onsite, loop-based projects within a circular economy context present an attractive solution.
- **Potential lobby intervention on policy for licences:** There are currently different limits for WtE air emission requirements on standard air emission licences; compared to biogas projects which have been exempted from air emission requirements.

7.3. Conclusion

There is a strong case and clear recommendation to package, position and communicate biogas projects as waste management projects. This will make them easier to understand by the finance community and enhance the likelihood of successful uptake of biogas in South Africa.

8. Interventions and recommendations

Interventions and recommendations can be broken into a short-term (1–5 years) strategy; and long term (5–15 years) strategy. Short-term interventions and recommendations focus on pipeline development and finance landscape analysis of sources and instruments. Long term interventions align with policy and regulatory recommendations and interventions. Strategic stakeholders are required to implement each strategy and ensure success.

Figure 4 below presents the investment strategy, short-term and long-term combined, for a viable ecosystem for development and investment in the biogas market. This highlights the existing and future investment opportunities in establishing and growing the full biogas investment value chain with the necessary stakeholders.

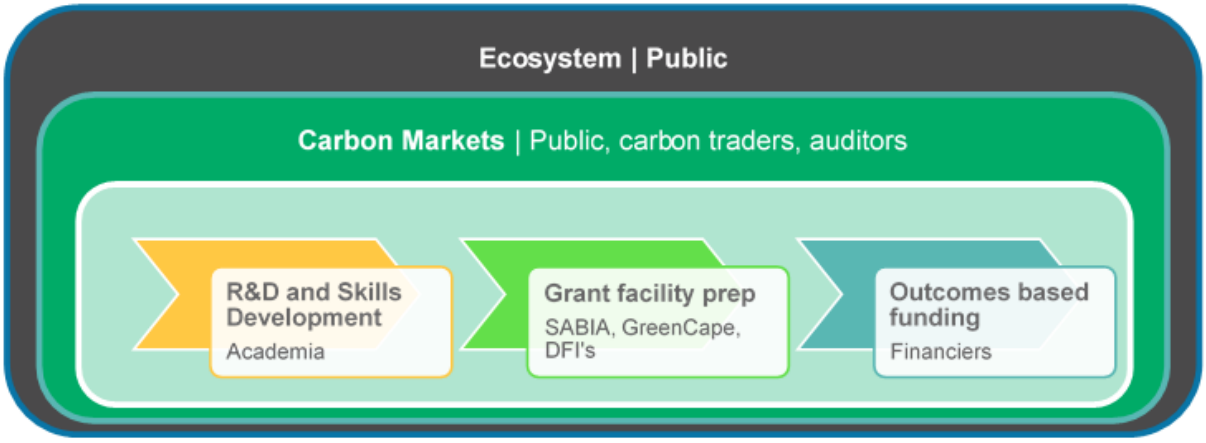


Figure 4: Biogas investment value chain ecosystem development with stakeholders

These areas of intervention are broken down below and a possible key stakeholder or mandate holder is provided that could drive the listed intervention.

8.1. Summary interventions and recommendations to enhance the investment case for biogas

Table 13 below provides a summary of the key recommendation and interventions to enhance the investment case for biogas that can be implemented in the short term (1-5 years). In each case, a recommendation is made on which entity is best placed to lead on each of these interventions. This gives a direct next step on how to take these forward.

Table 13: Summary of the key recommendation and interventions to enhance the investment case for biogas

Recommendation/ Intervention	Key stakeholders
8.1.1 Adapt value proposition to focus on waste rather than electricity	Industry associations Individual developers & financiers
8.1.2 Appoint an independent expert to assess viable biogas projects – third-party due diligence (to build pipeline for investors)	Industry associations Fund managers DFIs Retail & Commercial Banks
8.1.3 Bundling investable biogas projects in a Special Purpose Vehicle (SPV) for a development facility	Project developers Fund managers
8.1.4 Project preparation incubation unit	DFIs Industry associations

	Fund managers
8.1.5 Standard of Practices	Industry associations

Given the nascent nature of the sector, these first interventions are focused on building the reputation of an investment-ready sector. If the sector is going to attract the needed finance these interventions can support building a pipeline of projects based on the adapted value proposition to focus on waste rather than electricity.

8.1.1. Value proposition based on waste management rather than electricity sales

International markets have relied on three main drivers to develop the biogas market (greenhouse gas reduction, waste management or electricity sales). In the South African case, all three of these motivations have been used to deliver small projects. However, it is increasingly clear from the evidence of successful projects and the needs of the finance community that designing biogas projects as waste management projects is more compatible with success than designing them as electricity projects. There is a primary income stream built into this model, which involves the treatment of waste and wastewater via gate fees, with a secondary inflow of funds for energy off-takers.[23]

Figure 5 illustrates the challenge associated with viewing biogas through the lens of energy provision compared to viewing biogas as a waste management solution.

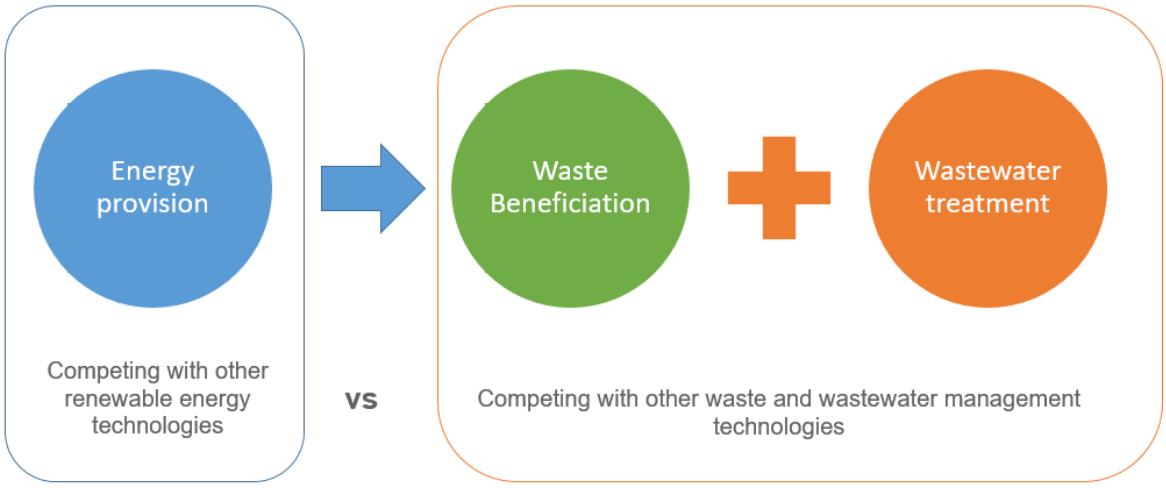


Figure 5: Defining a viable business case for biogas projects

Biogas projects developed as solely energy provision projects are currently not able to compete with wind or solar on a cost-competitive basis. This may change as the technology becomes more widely used and implementation costs decrease. On the solar front, the global average price for commercial solar PV electricity in 2020/21 was R0.86 per kWh, down from R5.33 per kWh in 2010.[24] The South African small-scale solar PV levelised cost of electricity is typically less than R1.00 per kWh. The South African small-scale embedded generation (SSEG) market is currently dominated by rooftop solar PV, given the competitive price, technical maturity, and ease of implementation of this technology.

[23] This design will have competition (other waste management solutions) and will depend heavily on enforcement of standards around landfills and illegal dumping for solid waste, and liquid discharges / effluent quality for waste water treatment, but is compatible with short and long term success.
[24] International Renewable Energy Agency (IRENA) (2021). *Renewable Energy Statistics 2021*. https://www.irena.org/publications/2021/Aug/Renewable-energy-statistics-2021

It has been proposed earlier[25] and confirmed by engagements done with financiers that biogas projects are likely to be more attractive if the business case is built as waste beneficiation and/or wastewater treatment solutions. The three potential target markets for waste beneficiation and wastewater treatment solutions are illustrated in Figure 6. These are the municipal market, commercial and industrial users, and the agriculture and agri-processing market.

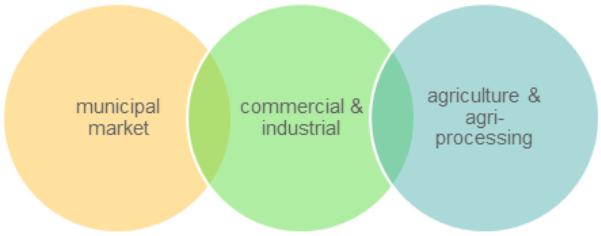


Figure 6: Three potential growth markets for waste beneficiation and wastewater treatment solutions

Each of these markets has particular challenges around waste beneficiation, but the predominant drivers for waste management solutions are presented in Figure 7.

Figure 7: Drivers promoting biogas implementation as waste management solutions

The legislation and regulation space is specifically providing the following drivers:

- Liquid waste to landfill ban (DFFE)
- Organic waste to landfill ban (DEADP, WC)[26]
- Effluent discharge costs (local municipalities)
- Land application discharge regulations (DWS)[27]

8.1.2. Appoint an independent expert to assess viable biogas projects

This recommendation proposes an independent, neutral expert on biogas assess bankable, investment-ready projects by scrutinising the key financial risks associated with biogas being feedstock availability and quality, the developer track record and experience, technology, policy and regulatory framework particular to the geographic region, project size etc. as outlined in Section 7.2.

The expert would perform the necessary stress tests on the project delivery and provide feedback to potential financiers. Conversely, the expert would also be able to provide assistance and/or guidance to potential developers in areas that were lacking to strengthen the investment case.

As the biogas projects are technical and nuanced, this recommendation would mitigate some of the viable model risk considerations for financial investors. These risk considerations are summarised in Table 14 for the various value propositions of biogas projects. These risk ratings are based on GreenCape's engagements with the biogas industry.

[25] SABIA Market Position Paper and GreenCape's 2021 Water Market Intelligence Report
[26] DEADP = Department of Environmental Affairs and Development Planning, WC = Western Cape.
[27] DWS – Department of Water and Sanitation

Table 14: Viable models risk considerations

Technology business case	Energy provision	Waste beneficiation	Wastewater treatment
Technology risk (Technical feasibility)	Medium	Medium	Low
Performance risk (Financial feasibility & bankability)	High	Medium	Low
Credit risk (Bankability)	High	Medium	High

Table 14 shows that waste beneficiation and wastewater treatment present a lower technology, performance and credit risk when compared to energy provision. This further supports the argument for a value proposition shift in the sector.

8.1.3. Bundling investable biogas projects in a Special Purpose Vehicle (SPV) for a development facility

The pooling of smaller, investable biogas projects assists financiers in mitigating risk across multiple entities and addresses fixed internal transaction costs with the benefit of economies-of-scale savings on smaller projects. Further to this, the bundled projects could be repeatable with similar designs and technology, thus saving construction time with the potential of lower costs for materials. Bundling is not new; however, it has had a muted presence in South Africa. In line with global trends, there is a strong argument that this will be a growing funding mechanism.

8.1.4. Project preparation incubation

Specialised project preparation incubators would assist biogas project developers with project preparation in feasibility and bankability to address quality control concerns and risk mitigation. This is a potential solution to the risk that financial investors highlight when project developers lack a track record of implemented projects. A recommendation would be for the industry associations, such as SABIA and WT4E[28], to support this potential incubator(s).

8.1.5. Standards of practice

The development of standards of practice for the development and implementation of biogas projects by the relevant industry associations can have a significant impact on the investment trends in these projects. Although biogas projects are often assessed on a project-to-project basis, having defined standards of practice, where possible, would reduce the transaction costs associated with due diligence and reduce the risk associated with uncommon variables when assessing the bankability of a project.

8.2. Long term interventions and recommendations

Long term interventions to enhance the investment case for biogas and the key stakeholders to drive and implement the recommendations are summarised in Table 15.

[28] Waste Transformation 4 Energy (WT4E) Association is the umbrella association for waste-to-energy (WtE) project developers, technologies suppliers, financiers and operators in Africa. Website: https://wt4e.com/

Table 15: Long term interventions to enhance the investment case for biogas

Recommendation/ Intervention	Key stakeholders
8.2.1 Policy development – biogas specific standards, waste (feedstock) separation and accessibility, promotion of renewable specialised gases	Industry associations DFFE, DALRRD, DMRE
8.2.2 Skills development – plant operators at various scales	CoGTA, DSI, SALGA Academia Industry associations
8.2.3 Industrialisation (supply chain and local manufacturing)	DTIC, DSI DFIs Industry associations
8.2.4 Outcome-based funding mechanism	Fund managers DFIs
8.2.5 Carbon markets	Fund managers DTIC
8.2.6 Infrastructure development for revenue model options	DMRE, DFFE, NERSA Provincial government Municipalities

Each of the interventions listed in Table 15 is detailed in the sections below. These are focused on building from the base set in the first short-term interventions to create a sustainable market that can produce the scale theorised in Table 4.

8.2.1. Policy development

As biogas industries are still considered nascent markets, there is very little legislation and policy that *directly* governs these industries. This results in extended project development periods due to licensing and permit authorities lacking knowledge and experience with regard to these technologies and the application of existing legislation to them. This recommendation proposes that policy and legislation be extended and developed specifically for biogas industries to reduce the project development time related to licensing and permitting, thereby also enabling pipelines and markets to grow more rapidly.

8.2.2. Skills development

Insights obtained from both technical and financial stakeholders on the skills that are required to support the investment into biogas project opportunities suggest that a focus on skills development would enable their more rapid deployment. The development of skills locally would enable local communities to benefit from (new) biogas job opportunities and those currently employed in these sectors (or other sectors) to upskill and adapt to the biogas technologies being introduced.

8.2.3. Industrialisation: Supply chain and local manufacturing

The importance of developing a local supply and manufacturing value chain links to the current CAPEX and OPEX related to biogas projects. These costs have a big impact on the attractiveness and risks associated with the business case for biogas. However, the rate of development of a local supply and manufacturing value chain is dependent on those services being required within existing projects and the pipeline of projects.

8.2.4. Outcomes-based funding mechanism

This recommendation proposes the development of an outcomes-based funding mechanism to support and incentivise local fund managers to increase investment in biogas projects. Either fund managers and/or projects would receive an incentive for achieving specified outcomes. However, an outcomes-

based funding mechanism can only be developed if the value proposition of biogas projects is well defined.

8.2.5. Carbon markets

With an increasing interest in the development of incentives for carbon reduction and offsetting initiatives, biogas industries have an opportunity to further strengthen their business cases by tapping into the developing carbon credit and trading markets. However, similar to the development of an outcomes-based funding mechanism, this recommendation can only be further capitalised upon if the value propositions of biogas projects are well defined.

8.2.6. Infrastructure development for revenue model options

The current viable revenue models for biogas projects are limited due to a lack of supporting infrastructure. For example, South Africa does not have an existing national gas grid which forces projects that focus on the valorisation of methane to include expensive gas bottling and upgrading technologies within the project's CAPEX cost. This recommendation, therefore, proposes that industry associations lobby and work with the government to develop infrastructure that will enable biogas projects to maximise the value of the outputs these projects produce.

9. Conclusion

There is a considerable amount of finance available for green economy and green energy projects. Project development is complicated and the South African legal landscape for biogas has complex and changing legal permitting requirements.

There is a strong case and clear recommendation to communicate and package projects as waste management projects. This will make them easier to understand by the finance community and enhance the likelihood of successful updates of biogas in South Africa.

This change requires a new industry investment strategy based on building the investment case on revenue from gate fees or payment for waste management services rather than relying on (stacking of) other revenue streams (i.e. electricity sales).

Locating facilities on-site is required for successful projects (reducing the need for infrastructure that can be used to distribute biogas and digestate to the market).

If this change in strategy is supported by a facility that provides pre-feasibility assessments (reduce finance risk), specialised project preparation (reducing due-diligence requirements) and project pooling (reducing the cost of capital) a considerable amount of finance available for green economy and green energy projects could be unlocked.

Annexure A: Funding mechanisms reviewed relevant to biogas

Table 16 provides a summary of the types of funders and specific institutions reviewed to obtain insight into the funding landscape for biogas projects. More detail is provided in the Excel database provided.

Table 16 funding mechanisms reviewed relevant to biogas

Type of disbursement channel	Name of disbursment channel	Name of funding opportunity	Financial instrument	Size of investment
Multilateral DFI	Africa Finance Corporation	Africa Finance Corporation Principle Investing	Debt; Equity	Debt: Unspecified; Equity: From US$10 million - US$50 million
Multilateral DFI	New Development Bank (BRICS Bank)	ZAR Bond Programme	Debt; Equity; Guarantee	Unspecified
Multilateral DFI	Climate Investment Funds (CIFs)	Clean Technology Fund (CTF) ; Strategic Climate Fund (SCF)	Debt; Equity; Guarantee	Unspecified
Multilateral DFI	The African Development Bank	Sustainable Energy Fund for Africa: Seed/Growth Capital (Component II)	Equity/Grant	US $ 10 million - US $ 30 million
Multilateral DFI	World Bank	World Bank Green Bonds	Debt	

Multilateral DFI	World Bank	International Development Association 18	Debt/Grant	
Multilateral DFI	International Finance Corporation (IFC)	International Finance Corporation (IFC)	Debt/Equity	Unspecified
Multilateral DFI	The African Development Bank	Sustainable Energy Fund for Africa: Project Preparation Grants (Component I)	Equity/Grant	US $ 30 million - US $ 75 million
Multilateral DFI	Nordic Development Fund (NDF)	The Energy and Environment Partnership Trust Fund (EEP Africa)	Grant	EUR 200 000 - EUR 1 million
Multilateral DFI	European Investment Bank (EIB)		Debt	
International FSD	Financial Sector Deepening Africa (FSD Africa)	FSD Africa Investments	Debt; Equity; Guarantee	Unspecified
Bilateral DFI	German Bank for Reconstruction and Development (Kreditanstalt fur Wiederaufbau - KfW)		Debt	

Bilateral DFI	The Danish Climate Investment Fund (KIF)		Debt/Equity/Guarantee	Unspecified
International DFI	The World Bank (as GEF Trustee)	Special Climate Change Fund	Grant	
International DFI	The World Bank (as GEF Trustee)		Grant	
International DFI	The World Bank (as GEF Trustee); United Nation Development Programme (UNDP)	Small Grants Programme (GEF SGP)	Grant	USD$ 50 000
Parastatal DFI	German Investment Corporation (DEG)		Debt/Equity	R 4 million - R 30 million
Parastatal DFI	State Bank of India	Working capital finance	Overdraft	Unspecified
National DFI; Public Agency	Industrial Development Corporation (IDC); South Africa National Energy Development Institution (SANEDI)	SUNREF (Sustainable Use of Natural Resources and Energy Financing) Programme South Africa	Debt	Unspecified
National DFI	Industrial Development Corporation (IDC)	AFD Green Energy Fund	Debt	Unspecified

National DFI	Industrial Development Corporation (IDC)	Green Tourism Incentive Programme	Grant	< R 1 million
National DFI	Industrial Development Corporation (IDC)	Manufacturing Competitiveness Enhancement Programme (MCEP) Industrial Financing Loan Facilities	Debt	< R 30 million
National DFI	Industrial Development Corporation (IDC)	Green Energy Efficiency Fund	Debt	R1 million - R50 million
National DFI	Industrial Development Corporation (IDC)	Technology Venture Capital Fund (TVC)	Debt/Equity	R1 million < R5 million
National DFI	Industrial Development Corporation (IDC)	AFD Green Energy Fund	Debt	Unspecified
National DFI	Industrial Development Corporation (IDC)	Manufacturing Industry Finance	Debt/Grant	< R 50 million
National DFI	Industrial Development Corporation (IDC)	IDC Gro-E Scheme	Debt/Equity	R 1 million - R1 billion
National DFI	National Empowerment Fund	Various	Debt	R 250 K - R75 million

National DFI	Development Bank of South Africa (DBSA)	GreenFund	Debt/Equity/Grant	Unspecified
National DFI	Development Bank of South Africa (DBSA)	Infrastructure Investment Programme for SA (IIPSA)	Debt	Unspecified
National DFI	Development Bank of South Africa (DBSA)	SADC Project Preparation and Development Facility	Grant/Subsidy/Guarantee	Unspecified
National DFI; NPC	Development Bank of South Africa (DBSA); South South North	Sustainable Settlements Facility	Grant/Subsidy/Rebate	
Provincial DFI	Eastern Cape Development Corporation	IMVABA Eastern Cape Provincial Co-operative Development Fund	Debt	R10,000 < R1,4 million
Provincial DFI	Eastern Cape Rural Development Agency (ECRDA)	ECRDA Rural Finance	Debt	Unspecified

Provincial DFI	Free State Development Corporation (FDC)	FDC SMME and Co-operatives Funding	Debt	Co-operatives Development Fund (<R500,000); Informal Sector Fund (R5,000 < R50,000); Franchise Development Fund (<R5 million); Youth Fund (R50,000 < R500,000); General Enterprise Development Fund (R50,000 < R5 million); Bridging Finance (construction and non-construction related) (R1 million < R5 million); Agriculture Development Fund - Production Loan (< R500,000); Agriculture Development Fund - Livestock Loan (< R100,000); Agricultural Related Need Industrial Equipment Loan (< R500,000).
Provincial DFI	The Gauteng Enterprise Propeller	The Gauteng Enterprise Propeller Financial Support	Debt	< R1,5 million
National DFI	Embassy of Finland	The Local Cooperation Fund	Grant	< €10 million
National DFI	Entreupreuneurial Development Bank of Netherlands (FMO)	Building Prospects	Debt/Equity/Guarantee	Unspecified

National DFI	Agence Francaise de Developpement - AFD		Debt/Grant/Guarantee	Unspecified
National DFI	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)	International Climate Initiative (IKI)	Grant	Unspecified
National DFI	Japan Bank for International Cooperation (JBIC)		Debt/Equity	Unspecified
National DFI	Japan International Cooperation Agency (JICA)		Debt/Grant	Unspecified
National DFI	PROPARCO		Equity	Unspecified
National DFI	United Kingdom Foreign Commonwealth Office	Prosperity Fund Programme	Grant	

The database (extract shown in Figure 8 and **Error! Reference source not found.** below) contains information on funding opportunities, the types of funding tools and institutions providing the funding, and contact details (that are publicly available). This includes information on national market players (e.g. commercial banks, microfinance banks, private equity/debt, venture capital/angel investors etc.), as well as international climate finance streams (e.g. climate funds, development finance institutions, multilateral institutions, bilateral development partners and domestic sources of finance.

	A	B
1	**Background:**	
2	South Africa's National Climate Change Response Policy (NCCRP) explicitly calls for the inclusion of the financial services sector in shaping South Africa's climate and green finance architecture alongside project developers and policymakers.	
3	South Africa's 3rd Biennial Update Report to The United Nations Framework Convention on Climate Change (BUR3) highlighted that catalysing the financing and investments required to proceed towards the low-carbon and climate-resilient economy remains an important challenge for the country.	
4	As such a number of stakholders have prioritised the development of resource and investment strategies, capacities, mechanisms, or instruments that support and enable implementation of climate change responses backed by climate finance.	
5	resources are intended to cover the costs of transitioning to a low-carbon global economy and to adapt to, or build resilience against, current and future climate change impact.	
6	The database provides a breakdown of available climate finance that can be used by biogas companies and projects in South Africa.	
7	This database is not an exhaustive resource and may be incomplete but is meant as a mechanism to support eco-system development and growth. It is the sole responsibility of the users of this database to verify and confirm data contained within this database.	
8	The authors hold no responsibility for the information continued in the document and cannot be held liable for the use thereof.	
9	**Contents and Instructions:**	
10	Each sheet is broken down into types of sources of climate finance (public, private and blended) these are covered by government (local and international), development finance institutions, commercial and other.	
11	Step 1: Select the relevant source of finance sheet	
12	Step 2: Sort sheet by sector with a focus on biogas: - Clean Energy - Energy Efficiency & Demand Side Management - Water conservation, supply & demand - Circular Economy	
13	Step 3: Sort sheet by investment instrument: - Grant - Concessional Debt - Debt - Equity - Budget Expenditure - Other	
14	Step 4: Check alignment of size of investment and investment opportunity information	
15	Step 5: Contact relevant financiers (include high level ask, market size estimate and basic company track record)	

Figure 8: Extract from finance database

The database analysed ~125 financing solutions valued at ~ZAR 25 billion. The database is ideal for a biogas entity seeking a broad range of funding solutions and financial incentives, with a largely South African focus.

	A	B	C	D	E	F	G	H	I	J
1	Public/ Privat	Type of source/ Intermedi	Name of source/ Intermediary of finance	Type of disbursement channel	Name of disbursment chan	Name of funding opportun	Financial instrument	Size of investment	Investment opportunity information	Direct Use
2	Public	Government	Member States	Multilateral DFI	Africa Finance Corporation	Africa Finance Corporation Principle Investing	Debt; Equity	Debt: Unspecified; Equity: From US$10 million – US$50 million	The Africa Finance Corporation (AFC) is an independent, majority private sector owned, multi-lateral African financial institution providing project structuring expertise and risk capital with 27 member countries. AFC invests in projects that will provide substantial, measurable benefit to a region or sector in the long term and will be the template for future infrastructure investment and development. However, the Corporation also considers the short term social, economic and environmental impact. Where possible, the projects utilize local resources and suppliers and jobs are created during both construction and operational phases. AFC invests equity or quasi-equity capital in projects or companies operating in its target sectors. AFC deploys capital at the development stage of a project or to fund expansions or buy-outs of existing companies or assets. In addition, AFC provides financing to developments on a project finance basis, and to existing firms	Mitigation
3	Public	Government	Member States	Multilateral DFI	New Development Bank (BRICS Bank)	ZAR Bond Programme	Debt; Equity; Guarantee	Unspecified	The New Development Bank (NDB) is a multilateral development bank established by BRICS countries to mobilise resources for infrastructure and sustainable development projects and mandate to issue green, social and sustainability bonds. The NDB registered the ZAR Bond Programme in South Africa in April 2019 with unlimited validity listed on Johannesburg Stock Exchange (JSE). Standard Bank of South Africa acts as a lead-arranger for the Programme and Absa Bank is a co-arranger. The size of of the bond totals ZAR 10bn ("US$ 700mn) with a focus on green and sustainability financing instruments. Green eligible sectors include: Agribusiness; Clean Transportation; Climate Change Adaptation; Energy-efficient building; Energy efficiency; Low carbon energy; Renewable energy; Sustainable land use and biodiversity; Sustainable waste management; Sustainable water management and irrigation; Pollution prevention and	Mitigation
4	Public	Government	14 donor countries: Australia; Canada; Denmark; France; Germany; Japan; South Korea; Netherlands; Norway; Spain; Sweden; Switzerland; UK; USA	Multilateral DFI	Climate Investment Funds (CIFs)	Clean Technology Fund (CTF); Strategic Climate Fund (SCF)	Debt; Equity; Guarantee	Unspecified	The $8 billion Climate Investment Funds (CIF) accelerates climate action by empowering transformations in clean technology, energy access, climate resilience, and sustainable forests in developing and middle income countries. The $5.4 billion Clean Technology Fund (CTF) provides developing countries with resources to scale up low carbon technologies with significant potential for long-term greenhouse gas emissions savings. The Dedicated Private Sector Programs (DPSP) are dedicated funding windows of the CTF that provide risk-appropriate capital to finance high-impact, large-scale private sector projects in clean technology, such as geothermal power, mini-grids, energy efficiency, and solar PV. The Private Sector Set Asides (PSSAs) allocate concessional financing on a competitive basis to projects that engage the private sector in sustainable forestry (FIP), climate resilience (PPCR), and energy access through renewable energy in	Mitigation
5	Public	Government	Governments of Denmark, USA, UK, Italy, Norway, Spain, and Sweden	Multilateral DFI	The African Development Bank	Sustainable Energy Fund for Africa: Seed/Growth Capital (Component II)	Equity/Grant	US $ 10 million – US $ 30 million	It will mainly target renewable energy and energy efficiency projects requiring total investments of USD$ 10 – 30 million range. Funding available for private sector only	Mitigation
	Public	Government	Member States	Multilateral DFI	World Bank	World Bank Green Bonds	Debt		World Bank Green Bonds are an opportunity to invest in climate solutions through a high	Mitigation

Figure 9: Extract from finance database - funding example

Annexure B: Overview of infrastructure in South Africa as it relates to biogas

Waste management and disposal

Waste generation – organics: South Africa generated 55.6 million tonnes of general waste in 2017, 19.3 million tonnes of which was organic waste.[29] According to the State of Waste, Report, 49.2% of organic waste was diverted/recycled, and this most likely is due to the diversion of garden greens. Approximately 10 million tonnes of organic waste ends up in landfills, providing a good opportunity for organic waste management interventions.

Waste management services and infrastructure: 59% of households had waste collection services, 2% had access to a communal collection point, and 34% had communal or own dump sites. This illustrates that many/most municipalities have struggled with basic service delivery (collection and disposal), resulting in the slow development of alternative waste treatment solutions, with recycling (plastic, paper, metals and glass) taking priority, followed by composting of organic waste (primarily garden greens).

Waste beneficiation infrastructure: Of 1,423 licensed waste management facilities, 704 (49%) were disposal sites, 202 were storage sites, 288 were for some form of recycling, recovery or treatment, and eight were for (landfill) gas extraction and flaring. From a municipal perspective, there are plans for organic waste beneficiation.

Agriculture and agri-processing

South Africa's biogas industry encompasses a growing number of projects implemented primarily through private funding at horticultural and livestock farms, abattoirs, municipal wastewater treatment plants and rural/domestic households.[30] The country has about 300 bio-digesters of which only 50 are registered commercial biogas plants, larger than 100kW. Biogas is estimated to have the potential to displace 2,500MW of grid electricity, equivalent to the size of Eskom's Arnot coal-fired power station in Mpumalanga, commissioned in 1975. Biogas production leads to several products such as biogas-to-electricity, biogas-to-fuel and biogas-to-transport which can be produced from the major source listed in **Error! Reference source not found.** (presented in the context of biogas-to-transport).

[29] Department of Environmental Affairs (2018). *South Africa State of Waste. A report on the state of the environment. Final draft report.* https://soer.environment.gov.za/soer/UploadLibraryImages/UploadDocuments/141119143510_state%20of%20Waste%20Report_2018.pdf

[30] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (2016). *Biogas Industry in South Africa. An Assessment of the Skills Need and Estimation of the Job Potential*. South-African German Energy Programme (SAGEN), https://sagen.org.za/publications/all-publications/19-assessment-of-skills-needs-and-estimation-of-the-job-potential-for-the-biogas-industry-in-south-africa

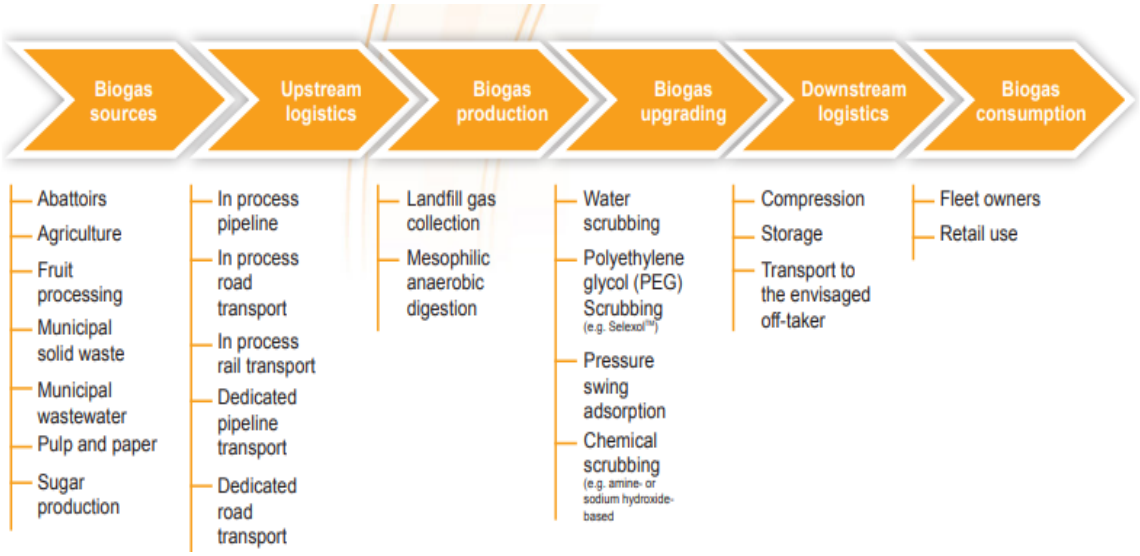


Figure 10: Biogas-to-transport value chain illustrating sources of biomass[31]

Abattoirs: Wastes generated include rumen/stomach content, manure and condemned material/trimming and blood. Except for blood, these types of waste have an attractive high biogas yield when anaerobically digested. The only limitation to these is the health and safety regulation concerning microbial quality.

Agriculture: In sugarcane production, the bagasse produced after pressing the cane can be a useful feedstock for biogas production. Although generally burned in the boilers of the sugar mill, the production of biogas may be an attractive alternative.[32] Wastes generated from farms include animal manure in the form of either dry manure (animal bedding) or wet slurries from intensive styles of livestock farming. These have been identified to have relatively low biogas potential, however, large cattle feedlots and chicken broiler farms can produce sizeable tonnages of waste and biogas. Waste streams are sometimes used to fertilise the land, e.g. fibre sludge from pulp mills[33] (Rashid et al., 2006), thereby preventing the need for landfilling. Because of the regulations around health and safety in SA, many farming operations collect, transport and treat their waste. Treatments include vermicomposting of organic manures and to a large extent treatment through biogas production to eliminate the emission of methane and the dangerous flux of effluents to water bodies. Biogas production at different scales is shown in Figure 11.

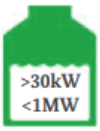
[31] Department of Environmental Affairs (2020). *Biogas Report: Facilitation of Large-Scale Uptake of Alternative Transport Fuels in South Africa – The Case for Biogas*. https://www.dffe.gov.za/sites/default/files/reports/bioagas_report.pdf

[32] For details see: Department of Environmental Affairs (2020). Biogas Report: Facilitation of Large-Scale Uptake of Alternative Transport Fuels in South Africa – The Case for Biogas. https://www.dffe.gov.za/sites/default/files/reports/bioagas_report.pdf

[33] Rashid, M. & Barry, D. & Goss, M. (2006). Paper Mill Biosolids Application to Agricultural Lands: Benefits and Environmental Concerns with Special Reference to Situation in Canada. *Soil Environ*. 25.

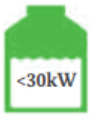
Large scale

- Self-consumption & fed into the grid e.g. abattoir, feedlot, agricultural processing
- Case studies / Developers: Bronkhorstspruit - B2W, Uilenkraal - CAE & Morgan Springs - BiogasSA
- 15-150 Tons of MSW/manure/abattoir/WWTW (Typical feedstock)



Medium scale

- Self-consumption (with possibility to feed into grid) e.g. restaurants, schools, farms
- Case studies / Developers: Jan Kempdorp - Ibert, WEC
- 2-15 Tons of MSW / manure / agricultural / abattoir / sewage (Typical feedstock)



Small scale

- Self-consumption e.g. household
- Case studies / Developers: Waste to Energy Programme - SANEDI, Agama & BiogasSA
- 0,1-2 Tons of MSW / manure / sewage (Typical feedstock)

Rural

- Self-consumption e.g. household with 2 cows
- Off grid, rural communities and individual households
- <1 Tons of MSW / manure / sewage (Typical feedstock)

Figure 11: Biogas production scales in South Africa[34]

Agricultural waste thus provides a potential feedstock for anaerobic digestion, however, these streams cannot be considered fully because of the existing barriers. These include the fact that ring-fencing the waste stream for a feasible biogas project is quite difficult when reviewing the national agro-waste potential. Barriers to quantifying the waste stream, include information on transport costs and the commercial value of such waste streams. Of the approximately 50 000 commercial cattle farms in SA, there are 70 listed commercial feedlots, most of which seem to own associated abattoirs and the remainder are small-scale cattle producers.

Water treatment

Metropolitan municipalities account for the largest segment of the biogas market in wastewater treatment works (WWTWs) in South Africa. Approximately 87% of the total volume of municipal wastewater is treated by the largest 16% of WWTWs[35], which are predominantly located in metropolitan municipalities. Nationally, the WWTWs produce a large amount of sewage sludge (~632 749 tonnes in 2017[36] that can be beneficiated to produce biogas and into electricity via combined heat and power (CHP) technology. This opportunity to offset the energy requirements of the WWTWs and the emission of greenhouse gases has not been extensively explored. The predominant treatment technologies employed in WWTWs comprise activated sludge (and its variations thereof), ponds and lagoons, and biofilters and solar drying beds for wastewater treatment, while anaerobic digesters, sludge lagoons/ponds, and belt press dewatering are used for sludge treatment.

[34] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (2016). *Biogas Industry in South Africa. An Assessment of the Skills Need and Estimation of the Job Potential*. South-African German Energy Programme (SAGEN), https://sagen.org.za/publications/all-publications/19-assessment-of-skills-needs-and-estimation-of-the-job-potential-for-the-biogas-industry-in-south-africa

[35] 10MLD and larger; according to data on WWTWs in the GreenDrop 2021 reports for each province.

[36] Department of Environmental Affairs (2018). *South Africa State of Waste. A report on the state of the environment. Final draft report*. https://soer.environment.gov.za/soer/UploadLibraryImages/UploadDocuments/141119143510_state%20of%20Waste%20Report_2018.pdf

According to the 2022 Green Drop report[37], there are only 50 WWTWs across the country that utilise anaerobic digesters and they are mainly for sludge treatment. Most anaerobic sludge digesters are located in Gauteng (56%), with 28 of 60 WWTWs (44%) in the province having operational digesters. The cities of Tshwane and Ekurhuleni collectively have 197 anaerobic digesters, with a total design capacity of 353 MLD. The rest of the anaerobic digesters are in KwaZulu Natal (5 out of 76), Mpumalanga (5 out of 76), Free State (4 out of 96), Western Cape (3 out of 158), Eastern Cape (2 out of 123), and the rest of the provinces have one each. The Department of Public Works also operates 8 anaerobic digesters in 115 of its WWTWs. As a guideline, only WWTWs that have a capacity of 10 MLD or greater are likely to have financially viable biogas and CHP projects and this translates to about 156 WWTWs (40%) (DWS, 2022). According to a study by SABIA in 2016, 87 WWTWs had a potential for biogas projects[38] and of these 39 plants were financially viable for CHP projects[39].

However, many anaerobic digesters are either fully committed, have limited spare capacity, are poorly managed and operated and/or are in various degrees of disrepair. Amongst the operational ones, the majority of them do not harvest biogas (methane) produced, but flare it (or just release it into the atmosphere). There is a skills gap among process controllers and their plant supervisors in sludge handling and biosolids standards across all municipalities. Sewage sludge generally provides relatively constant feedstock volumes and quality for anaerobic digesters (unlike most commercial and industrial effluent). However, due to the skills gap and the dysfunctionality of WWTWs nationally, with 39% reported to be in a critical state, the consistency of the feedstock is jeopardised. Any limitations in wastewater and/or sludge treatment will negatively impact the overall efficiency of the WWTWs. The successful implementation of biogas projects in municipal WWTWs will require new anaerobic digesters and effluent treatment units to ensure good quality and consistent feedstock. Existing ones will also need to be refurbished.

Electricity

The eleven supply areas within the Eskom transmission network are limited to about 30 GW of generation capacity.[40] The generation connection capacity available within each supply area is shown in Figure 12. The power corridors of the Greater Cape area comprising the Western Cape, Northern Cape and Eastern Cape networks are highly constrained and very limited generation can be accommodated further to what has already been approved. Substantial upstream network strengthening will therefore be required to facilitate new generation capacity in these areas. In contrast, the KwaZulu-Natal, Mpumalanga, Gauteng and North West supply areas can accommodate between 4 GW to 7 GW of generation each.[41]

Further information on the local transformation capacity at substations within each province is also available. An example of this is depicted in Figure 13 for the case of the Western Cape.

[37] Department of Water and Sanitation (2022). *2022 Green Drop Report*. https://ws.dws.gov.za/iris/releases/Report_DPW_Rev02_29Mar22_MN%20web.pdf

[38] Includes WWTWs with required essential infrastructure to produce biogas but may not necessarily be technically feasible or financially viable for CHP projects

[39] WWTWs that will recover invested capital as well as operational and maintenance expenditure over the projected life cycle ~15years, through electricity cost savings.

[40] Eskom (2021). *Transmission Generation Connection Capacity Assessment of the 2023 Transmission Network (GCCA – 2023)* Phase 2 Reference No.: Gp_21/182 October 2021. https://www.eskom.co.za/wp-content/uploads/2021/10/GCCA-2023-Phase2.pdf

[41] ibid.

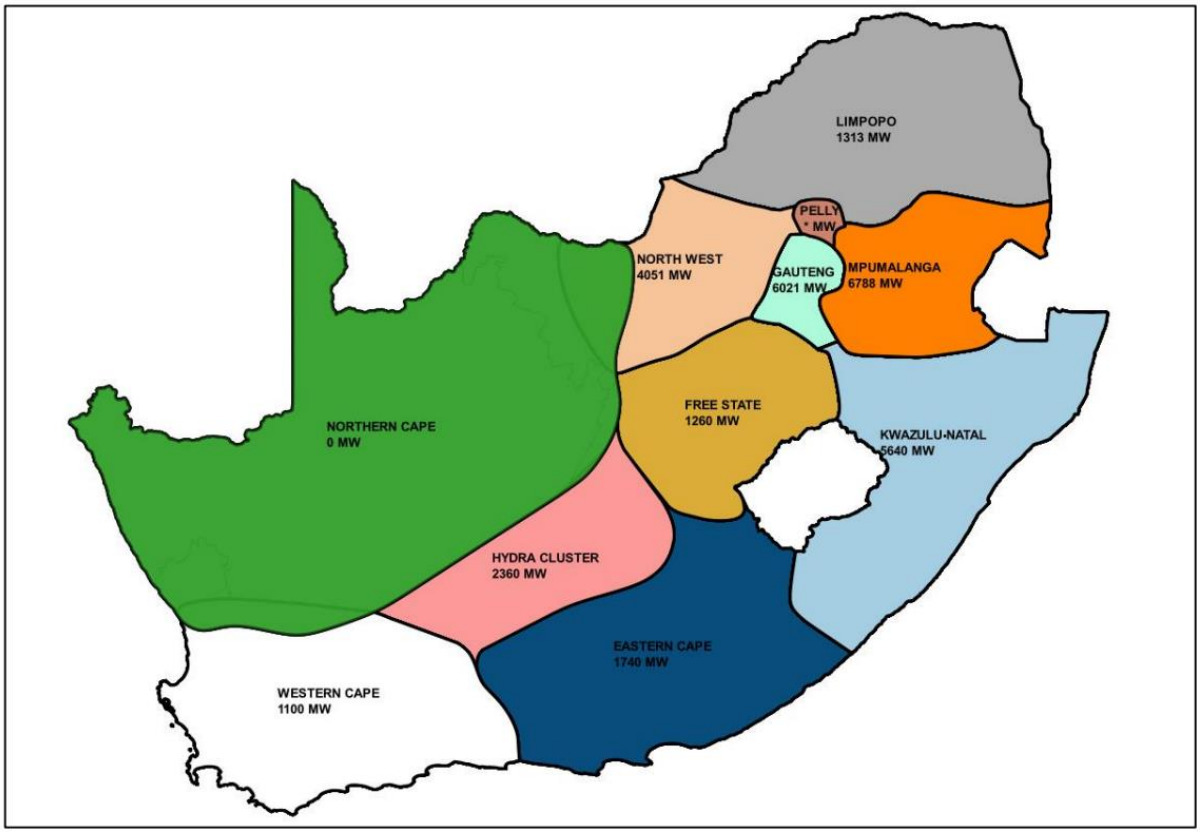


Figure 12: Eskom supply area capacity[42]

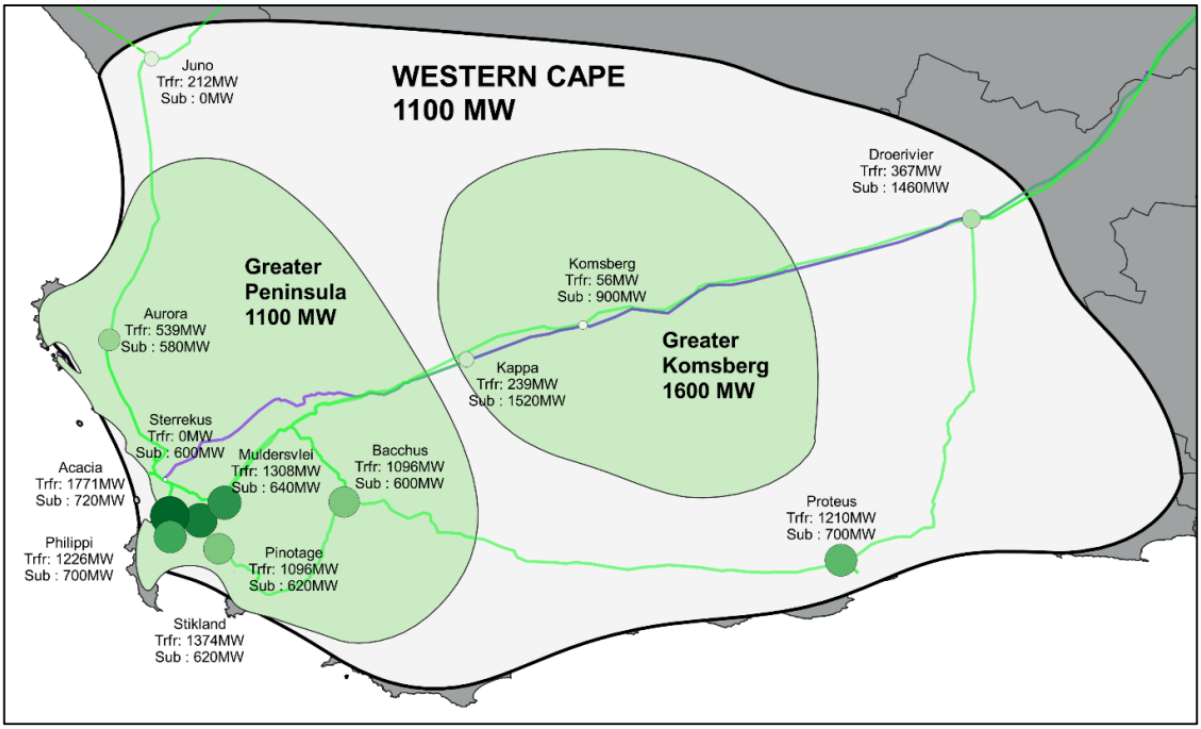


Figure 13: Example of information available on local infrastructure capacity: Western Cape[43]

[42] ibid.
[43] ibid.

Support infrastructure available

An infrastructure and support evaluation for RSA was completed within the BioEnergy Atlas[44] to demonstrate if the infrastructure is adequately placed to support bioenergy projects. The evaluation indicated that power stations and electrical transmission/distribution infrastructure are adequately placed in respect of economic activity, but less so in respect of population. New transmission infrastructure is planned by Eskom in areas such as the rural Eastern Cape, the KwaZulu-Natal Midlands and western Limpopo which are considered areas that are poorly served. There is generally good infrastructure cover in areas where potential feedstock is produced (Figure 14).

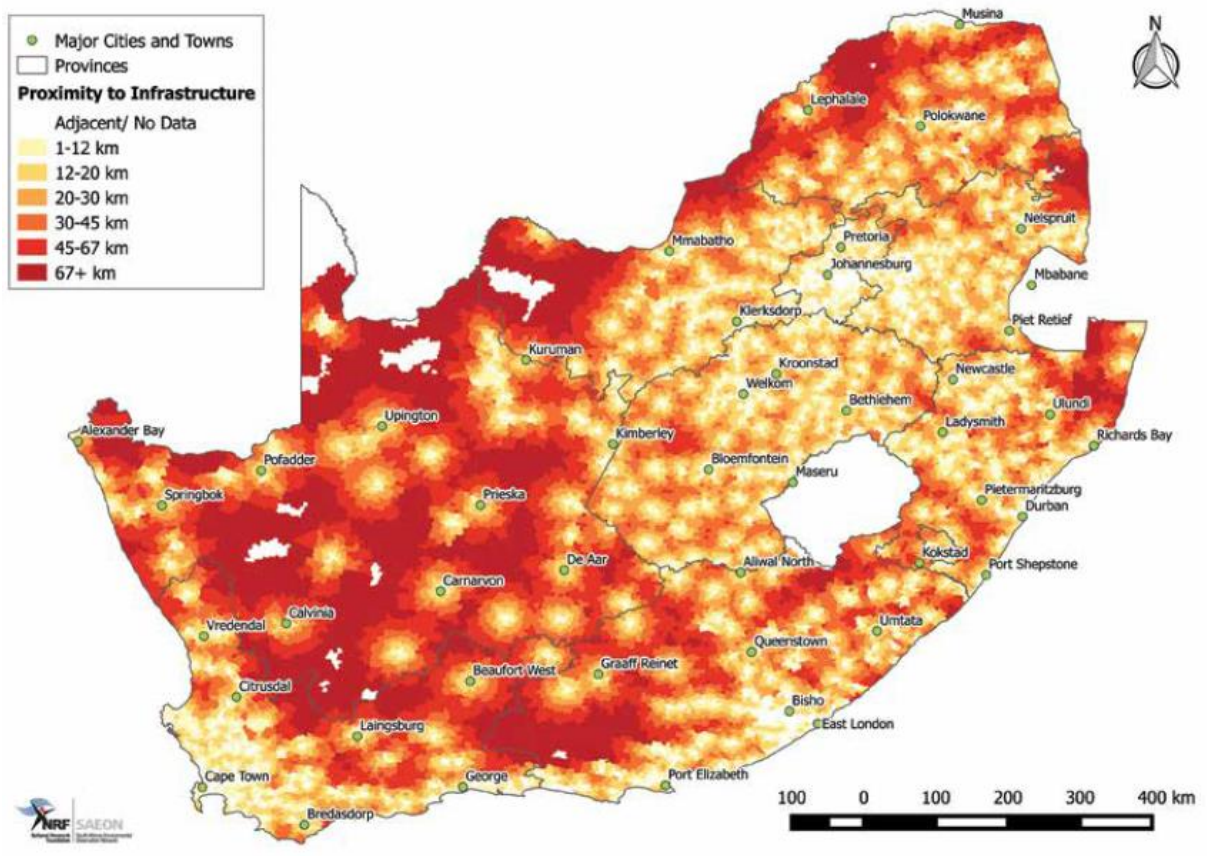


Figure 14: Proximity of the closest infrastructure (of all types) to each location in South Africa[45]

Figure 14 shows that South Africa has good transport and logistical infrastructure in the eastern parts of the country and the Western Cape which makes accessibility to feedstock ideal. Projects that are established more than 20 km away from feedstock often have higher transportation costs. This has implications on both feedstock security and accessibility as well as the off-take potential for digestate produced.

[44] Hugo, W (Ed), 2016. *BioEnergy Atlas for South Africa – Synopsis Report*, Department of Science and Technology, https://www.saeon.ac.za/wp-content/uploads/2021/02/Bio-Energy-Atlas.pdf
[45] ibid.