6 Republic of South Africa

6.1 Market overview

The South African biogas sector is still in a nascent state, due to a historically slow rate of uptake as a result of the poor track record for implementing projects with the local context. This means that there is general inexperience in designing, constructing and operating of biogas projects. Increased uptake of biogas technology in conjunction with development of local expertise is therefore expected to assist the industry in maturing to a level where biogas technology and the industry is commercially sustainable.

Some of the complexities faced by the biogas sector in the Republic of South Africa (RSA) include optimisation of multiple revenue streams and the need for feedstock security, while several market barriers such as cost of digestate management and low landfill gate fees hamper growth. Biogas stakeholders need to understand the current viable project models in RSA[86], and follow a comprehensive project development methodology to assist in the development of bankable and successfully implemented projects.

Development of the South African biogas industry over the next five to ten years is therefore expected to be driven by the increasingly stringent environmental regulations seeking to minimise impacts of environmental degradation and climate change; social factors addressing access to services; and legislative factors that simplify the regulatory complexity in the sector all of which increase economic viability of projects.

6.2 PESTLE or Macro Analysis

A PESTLE analysis was carried out to outline the macro-environmental factors that may impact the success of the DiBiCoo project in RSA. In terms of the six aspects of the PESTLE analysis, the key factors that will have a significant effect on the DiBiCoo project in the RSA are economic and environmental. With the lack of clarity on funding of larger projects as well as stringent/rigid environmental frameworks, project development is faced with substantially prolonged processes, generally in excess of three years at best. However, the legislative and policy landscape is in the process of changing to more favourable conditions. Positive developments include bans for all organic and liquid waste from landfill (Department of Environmental Affairs, 2013) and Integrated Resource Plan (IRP) (Department of Energy, 2019) for development of biogas projects.

6.2.1 Political and legal

RSA has enjoyed a prolonged period of relatively stable government, with the constitution of the different levels of government showing limited shifts since 1994. However, the ongoing inquiry into allegations into state capture[87] highlights a few negatives that include increase in corruption and lack of accountability. In recent years, this has led to the growth of opposition parties. A positive effect, as this allows more accountability within governance bodies.

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[86] See Table 32: Current viable biogas project models (UNIDO, 2018)

[87] Website of the Commission of Inquiry Into Allegations of State Capture can be accessed in: https://sastatecapture.org.za/

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Over the last 10 years, there has been a stronger focus on correcting the injustices of the past, including a strong focus on developing local enterprises and small, medium and micro-sized enterprises (SMMEs), particularly from previously disadvantaged groups. This has also led to legislative policies supportive towards growing the participation of local businesses in the country. As such, one of the routes for an exporting partner is to identify and work with a local partner within the ambits of the law and working on supporting the aims of transformation.

With increased interest in investing in both basic infrastructures (such as source separation, improvement in transfer stations and waste disposal sites) for waste management, the associated increase in regulation and policy has led to a need for good understanding of the policy and legislation that has been recently promulgated, as well as that in the process of promulgation. The bulk of the legislation and policy that has been recently developed focuses on environmental protection, and in recent years there have been many issues identified (such as outdated legislation, lack of understanding of emerging technologies amongst regulators) in the green economy sectors with suitability of legislation, understanding of legislation and implication thereof. As such this is still a strongly developmental area, with one of the biggest positives being the engagement with both private and public stakeholders across different sectors in order to ensure better promulgation and implementation.

These implications include understanding the recently promulgated liquid and organic waste to landfill bans and Carbon Tax Act (CTA) (2019). In addition, increased expertise in implementing and improvement of existing Acts, in the form of operations and understanding the potential for public private partnerships (PPP), can help existing wastewater treatment works (WWTWs), both in the private and public sectors, can assist in achieving wastewater discharge standards being met as per National Water Act (NWA) (1998). These are considered key drivers as they impact the costing and time taken for a project developer to complete the environmental impact considerations, licensing and permits required.

The developments with the renewable energy sector impact the potential of the off-take markets for the products produced by a biogas plant. GreenCape's 2020 Energy Services Market Intelligence report highlights these developments which include the amendment of Schedule 2 of the Electricity Regulation Act 4 of 2006 on 10 November 2017. Certain power generation facilities of less than 1 MW in size are now exempted from having a generation license provided an installation meets the criteria as stipulated in the amended schedule. Another development is the Integrated Resource Plan (IRP) 20191 which was promulgated in October 2019. The updated document allocates 500 MW per annum for distributed generation for own use of between 1 MW and 10 MW, starting in 2020.

6.2.2 Economic

RSA has a highly developed economy, primarily built on extraction of natural resources such as gold, platinum and coal. In addition to being one of the world's largest exporters of gold and platinum, the country's economy is characterised by a wide range of industries producing goods for both local and export markets. However, there is room to expand the current economic sectors further, whilst also focusing on the development of additional sectors and industries.

As a super-exporter, top 1% of the country's exporters produce 80 products, which account for 75% of South Africa's export market (Trade and Investment Promotion Agency, 2014). The

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export power is however almost evenly balanced with the import needs. During 2018, the country imported and exported goods worth US$92.6 billion and US$93.6 billion respectively (WITS, 2020).

As a growing economy, RSA is focusing on reducing the import bill, and growing the export income, and as such has seen strong growth in foreign direct investment (FDI). Within sub-Saharan Africa, 16.5% of the US$32 billion that was invested in the 46 sub-Saharan countries in 2018 was invested in RSA. In addition to being a prime destination for FDI, investment in RSA increased by 165% between 2017 and 2018 (from US$2 billion to US$5.3 billion) (United Nations Conference on Trade and Development, 2019). This is testament to the potential for growth of the economy, with businesses, institutions, and regulatory landscape in RSA geared to use the opportunity.

Economic growth in RSA has not been without challenges. In addition to the global economic crisis of 2008, challenges in power (electricity) production has dampened growth significantly over the last 10 years. However, some of the challenges are being addressed - with the World Economic Forum (WEF) reporting that RSA's competitiveness has regained momentum after the recent political landscape shift. This has seen the country moving up 7 places to 60th in WEF's 2019 Global Competitiveness Report (World Economic Forum, 2019).

As an economy geared towards accelerated growth, with increased demand for energy in order to both grow industry and increase access to (cheap) power sources, RSA is therefore a good prospect for the development of renewable and sustainable energy sources in its growth towards a more resilient and sustainable economy. That, and the challenges in provision of electricity due to ageing power stations therefore make a good case for the expansion of alternative (renewable) energy solutions, including energy from biogas.

Other indicators indicated in WEF's 2019 Global Competitiveness Report that are of interest and are indicative of growth potential of the economy include:

- well-developed equity, insurance, and credit markets, placing RSA as a regional financial hub (score of 83.2, 19th place);
- advanced transport infrastructure (score of 58.7, 45th place) and is among the top countries in Africa for market size (score of 68.6, 35th place);
- improved institutional quality (+3.3 points, 55th). Some aspects of this category have achieved remarkable progress, including restored balance of powers across different state entities (+7.7 points, 16th), enhanced administrative efficiency of the public sector (+6.3, 39th) and corporate governance (+3.3, 26th).

In contrast, there are other aspects that show deficiency within WEF's 2019 Global Competitiveness Report, and although possibly a worry for development, they provide additional streams for development. These include:

- security (42.7, 135th) remains one of the main restraints to South Africa's competitiveness;
- transparency (43.0, 62nd) and government adaptability to change (39.6, 100th), although there is continuous work at addressing these, particularly in terms of public sector governance;
- relatively low business dynamism (61.9, 60th), which is inhibited by insolvency regulation and administrative burdens to initiate a business;

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- limited labour market flexibility (52.1, 111th). For instance, flexibility of wage determination is limited (41.1, 134th) and hiring foreign labour is difficult (40.6, 123rd), the latter often leading to delays where specialised skills are not available locally;
- dependence on export of mineral resources places a heavy dependence on global market prices, often affecting the country's economic outlook and making unemployment reduction efforts challenging.

6.2.3 Social

As a developing economy, South Africa has shown improvement in a number of social indicators, including increasing life expectancy (Figure 31), decreasing mortality rate (Figure 32), increasing per capita income and increasing average disposable income. Although these are all positive, inadequate planning to accommodate these changes inadvertently puts a significant strain on provision of services.

In addition, increasing immigration from other African countries coupled with increasing rural-to-urban migration has also put a significant burden on service provision in urban areas. In terms of waste management specifically, the higher per capita income, increasing average disposable income, changes in lifestyles as access leads to changes in buying behaviour will lead to increasing amount of waste generation per capita in the short-medium term.

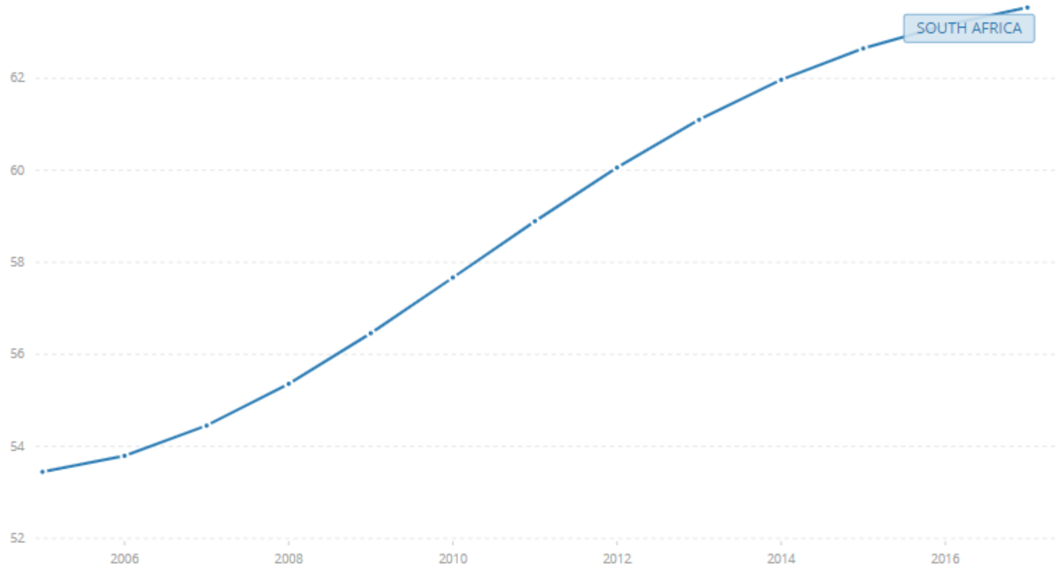

Figure 31: Life expectancy in South Africa (Wolrd Bank, 2020)

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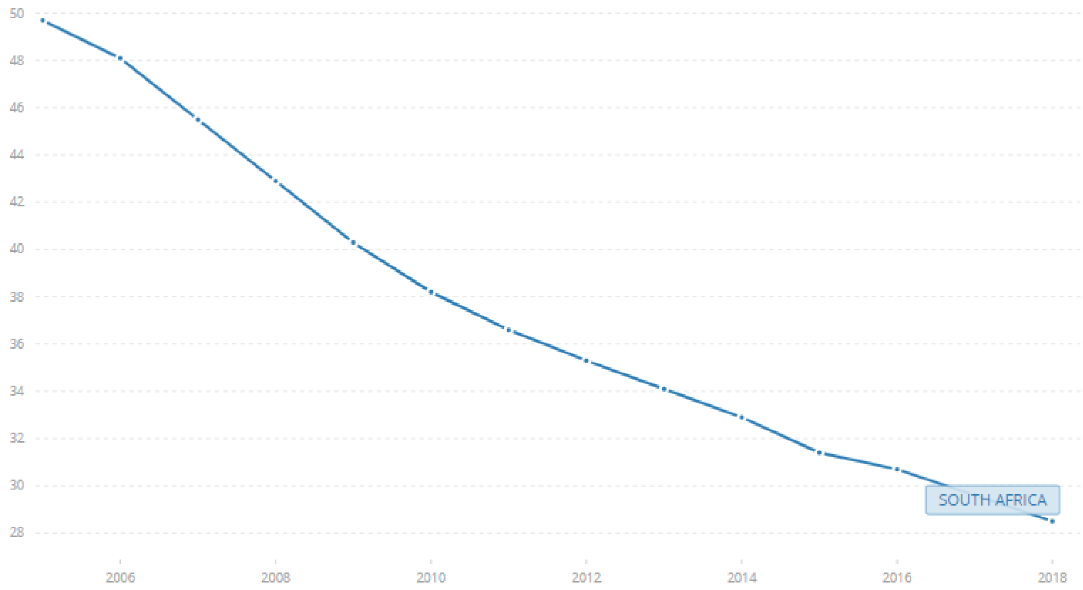

Figure 32: Mortality rate per 1000 live births in South Africa (World Bank, 2020)

Although landfill is still perceived as the cheapest option for waste management, there are a number of factors that are positive for the biogas market in RSA, viz. the need for diversification of energy mix due to deficiencies from Eskom (RSA's primary energy provider); and the general perception around sustainable waste management practices leading job creation. In a country grappling with an unemployment rate of 29% (Statistics South Africa, 2020), the job creation potential associated with the i.e. development and implementation of waste diversion practices makes this a priority area for government support.);

Hence AD is a good technology for implementation in addressing a number of the social issues which RSA is currently facing.

6.2.4 Technological

The development of biogas projects may be designed to meet one or a combination of three pressing needs:

- Energy provision;
- Waste management;
- Sanitation.

In RSA, abundance of lower cost energy sources (primarily coal for electricity) and low cost of landfill have for the most part limited the development of biogas technology as means for energy provision and waste management respectively. In addition, biogas generated as a by-product from sanitation within wastewater treatment works (WWTW) has in most cases not been captured and used further.

The technology itself has been tried and tested more recently in various environments within RSA and has exhibited good outcomes in areas with homogeneous solid based feedstock - primarily in farm/agriculture settings. Many of the installations are under 10 years old and with the exception of one with an installed capacity of 5.5MW, most fall under 1MW (typically 250 – 600kW installed capacity).

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Wastewater treatment works are a second and much larger sector that has historically had the AD installed, but many of the plants are now defunct or operating inefficiently. Due to the age of installations at WWTW, most of them were designed to treat sewerage and flare off the gas, with no energy production.

Research & development activities exist and are growing at tertiary education level institutions and research institutions such as Council for Scientific and Industrial Research (CSIR) and South African National Energy Development Institute (SANEDI). The National Research Foundation (NRF) has funded several postgraduate projects related to various application of biogas technologies, such as at schools, households, industrial wastewater treatment and sites in the agriculture sector. The local knowledge developed in RSA does enhance the prospect of biogas potential.

The technological gaps identified from existing projects currently exist with feedstock preparation particularly within municipal waste. These gaps showed issues that include:

- Poor or lack of source separation;
- And limited skills to design, build and operate within the public sector (most biogas projects in the public sector have outsourced the technology design, construction and in some cases the operation).

6.2.5 Environmental

With increasing awareness of the environmental and climate change impact of coal-based electricity and fossil-fuels, demand for environmentally friendly technologies is increasing. At a higher level, RSA has committed to contributing and achieving the SDGs which the flexibility of biogas technologies allows it to be implemented in energy, water and waste sectors.

A review into the country's development history would provide such insight – focusing on sustainable development. In the early 1990s, RSA's transition came with policies and plans that aimed to realign the governance of matters influencing the environment, the economy and society. To illustrate this new intent, new legislative acts focusing on resource management, conservation and preservation were promulgated (e.g. National Water Act (NWA) (1998) and the National Environmental Management Act (NEMA) (2008)). There is increasing legislation supporting both environmental protection as well as sustainable waste management practices.

Therefore, anaerobic digestion (AD) does mitigate both provision of energy demand and lack of efficient waste management and sanitation by addressing issues such as poor quality effluent entering water bodies and poor air quality as a result of coal fired power plants.

6.3 Market Characterization and Definition

The South African biogas industry is in an infant state, as insights gained from established projects demonstrated that there is a low rate of uptake and general inexperience in designing, constructing and operating of biogas facilities. The drivers that support and assist the South African biogas industry in maturing include economic, environmental, social and legislative factors. The key drivers of increased biogas technology uptake include more the increasing costs of organic waste disposal, both solid and liquid forms, and the demand for energy security and diverse energy mix (GreenCape, 2017).

GreenCape's market intelligence gained through stakeholder engagements showed that there is a large potential and opportunity for biogas project implementation. Much of the research to

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date to understand the viability of biogas in South Africa has been focused on the technical models used to develop biogas projects. However, due to the lack of commercial success a number of biogas projects that have been implemented, site owner and investors' confidence for biogas projects are considered to be low (UNIDO, 2018).

Recent research has focused on understanding the conditions for bankable biogas projects and the factors that will enable appropriate markets to develop biogas projects. Currently, bankable biogas projects with the private sector are site specific and only strong under certain conditions. These include situations where large volumes of feedstock of good quality are available, waste management costs are high, and there are high energy requirements (electric or heat) on-site or in a close and viable proximity (GreenCape, 2017).

The South African biogas industry is small compared to many other countries. It is estimated that there are currently around 500 digesters in RSA, 200 of which are at wastewater treatment works (GreenCape, 2017). However, of the remaining 300 digesters, the majority are small-scale domestic digesters and very few biogas projects within the commercial and industrial (C&I) sector. Most existing C&I biogas projects are embedded within a site for their own usage and, are initiated and driven by the private sector.

6.3.1 Market form

The South African biogas market, in common with other developing countries, is a growing market. There have been some "innovators" and possibly "early adopters" within the biogas market within RSA. The South African biogas market has reached a "tipping point", as shown in Figure 33, where the industry will grow and mature by unlocking the opportunities and barriers that improve the business case viability for biogas projects.

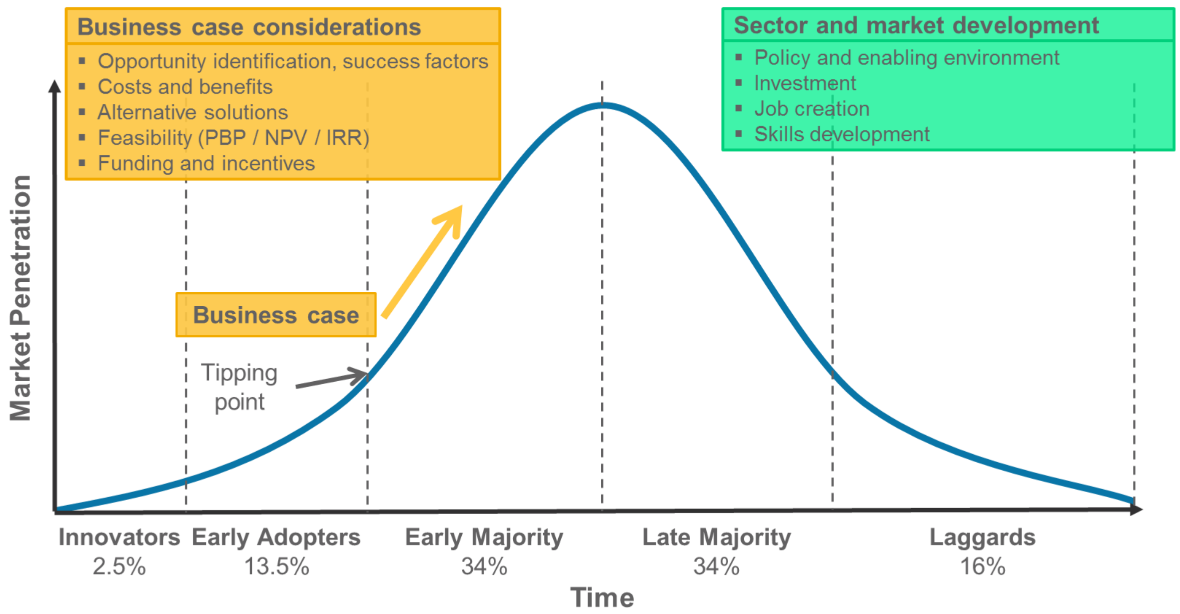

Figure 33: Roger's diffusion of innovation model showing key elements for consideration to build a business case and for market and sector development (GreenCape, 2017)

This market is in its infancy compared to most European markets. Existing barriers are strong financial business case except for very large-scale projects, low cost of competing energy

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sources, until recently no grid access, not permitted to generated above 1MW for own consumption until recently, long-term security in feedstock supply, and significant regulatory hurdles. Despite these challenges, several projects have still been commercialized in RSA.

The drivers for the uptake of biogas in RSA have mainly originated within the private sector. These drivers include several economic and environmental factors (GreenCape, 2017):

- **Waste disposal costs –** These costs are relatively low in RSA but becoming higher for particular types of organic waste such as abattoir and liquid waste which is no longer allowed to be disposed of at landfills.
- **Electricity price increases** – As Eskom continues to struggle to meet the energy demand, electricity prices have consistently increased above inflation, with over a 300% increase since 2004.
- **Increased energy security –** As a result of on-going load shedding, there is an increased need to produce and utilise energy on-site, and biogas (with its ability to be stored) can meet this demand.
- **Lower carbon footprint -** Potentially beneficial for agricultural exports to regions with increasingly environmentally conscious consumers and government policies, such as the European Union[88]. In addition, implementation would reduce pressure from regulators with regards to current environmental legislation violations such as water discharge standards and landfill bans.

6.3.2 Market size and growth

Typically, within RSA, the biogas market is defined within three sub sections, viz. small-scale sector, private sector and public sector. The small-scale sector includes residential and domestic biogas digesters which usually have a power supply capacity of less than 25kW (cooking, lighting and sanitation). The private sector is often referred to as C&I sector and has digesters with a typically capacity ranging between 25kW – 5MW (heating and electricity generation)[89]. GreenCape (2019) indicated ZAR14 billion was spent on municipal water & sanitation services in RSA in 2018. The public (or municipal) sector refers to mainly WWTW and solid waste facilities that incorporate AD technologies. GreenCape (2019) reported that RSA's largest water market is the municipal sector and that ZAR30 billion per annum was invested in water & sanitation infrastructure budget in 2017.

Biogas has the potential to tackle the energy shortage crisis at base load and the consumption of organic waste to produce either bio methane (electricity, heating and cooling, transport fuel) and digestate (liquid & solid). As such, the market for biogas is therefore defined by energy demand as RSA has a significant energy supply shortage. However, with competing energy sources with lower cost, the main driver for biogas has be shown to be waste treatment (solid organic and liquid organic).

[88] Note that a full life cycle analysis (LCA) would need to be done to confirm that the biogas system has a lower carbon footprint to business as usual or a system to which it is to be compared.

[89] Mutungwazi, A., Mukumba, P., & Makaka, G. (2018). Biogas digester types installed in South Africa: A review. Renewable and Sustainable Energy Reviews, 81(October 2017), 172–180. https://doi.org/10.1016/j.rser.2017.07.051

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GreenCape's[90] research indicates that South Africa has 28 C&I biogas projects and five landfill gas (LFG) projects, one of which is part of the Renewable Energy Independent Power Producers Procurement (REIPPP) programme. The 28 C&I biogas projects energy equivalent sizes range from 12.5 kW to 5.5 MW with various feedstock being used. The feedstock breakdown for these projects include five energy crop farms, eight livestock farms, four abattoirs, four water and/or wastewater treatment sites, and seven food and general waste generating sites. All of these 28 C&I projects are private sector projects and either generate electricity and heat on-site usage or use the biogas as a fuel replacement.

The current South African biogas market is considered in a very slow growth phase due to the factors that impact the business case for the projects being project-specific (such as of site requirements, on-site energy demand, financial structuring). UNIDO's waste-to-energy project identified success conditions for bankable biogas projects within RSA as of 31 March 2018. These success conditions were determined through market research and stakeholder engagements. The resulting viable models for biogas projects are summarised in Table 32.

[90] BIOGAS IN SOUTH AFRICA: LESSONS LEARNT, GreenCape Presentation 2020, Yaseen Salie & Tawanda Sango

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Table 32: Current viable biogas project models (UNIDO, 2018)

Size	Small	Medium
Type	Private	Project finance or SPV
ZAR value	***R2 - R20 million**	***R20 - R400 million**
Typical project size	< 500kW	> 500kW
Key component	****Site/developer collateral**	Off-take guarantee (gas and or electricity), Wheel-ing agreement, Feedstock security with alternatives sources
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 project	Portion of feedstock or offtake on-site Need digestate management process (net zero fi-nancial impact)
Site options	Abattoir, feedlots, chicken farms, malls, piggeries, food processing, fruit, and vegetable processing	Mega farm (single supply), centralised farm (mul-tiple feedstock supply)
Revenue model	Electricity and heat and /or gas and offset disposal fees	Premium on electricity sales (banking on green energy premium or Eskom rising above fixed es-calation), 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 re-finance residual value (Debt re-quires min tail of 3 years) DSCR - 1.3	D:E - 70:30 IRR - 18-25% Debt tenor - 12 years Debt requires tail of 3 years DSCR - 1.3, Debt reserve account 6 months (in-terest and capital)
Cover	Site owner/developer balance sheet strength (different revenue stream options), land collateral	• Cession rights, buy back options • Independent assessment for feedstock/de-sign • PR guarantees of plant • Continuous feedstock analysis (visual or test) • Insurance options
Key considerations	No revenue considered during the first 6-12-month commission-ing	No revenue considered during 6- 12-month com-missioning 50% buffer on feedstock supply 1 main feedstock supplier with 2 secondary op-tions

***An indicative CAPEX cost for a biogas plant is R40 million/MW, provided by industry experts.
****A developer could finance a biogas plant through their own balance sheet, secured through an offtake agree-ment 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 values above or below is quoted, but it requires a justification for the values quoted.
D:E – debt to equity ratio, IRR – internal rate of return, DSCR – debt service cover ratio,
PR – performance ratio

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In addition, a study conducted by EcoMetrix Africa (Pty) Ltd in 2016[91] is conservative as they looked at the biogas potential from major feedstock. In the study they concluded that South Africa had biogas production potential around 3 million Nm^3 per day.

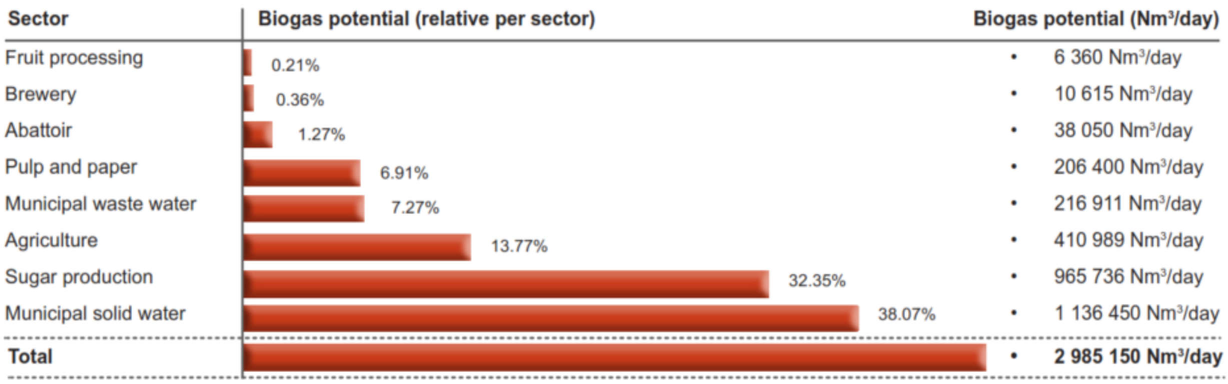

Figure 34: Biogas potential relative to sector (Ecometrix Africa, 2016)

Figure 34 suggests a potential for 700MW installed capacity (1.58% of existing installed capacity within RSA) using 1 Nm3 of biogas at 60% methane is 20 MJ or 5.6 kWh. However, through engaging with existing plant owners and developers, the market focus has been on agricultural and agri-processing residues due to the difficulties faced when engaging with municipalities with regards to municipal solid water and municipal wastewater. The sugar production sector has already invested in biofuel production from its residues.

Although the biogas market within RSA is considered growing (albeit slowly), there exist potential for the market increased growth and acceleration due to the current energy crisis, the limited landfill airspace within the metropolitan areas of RSA and liquid and organic waste bans due to resulting contamination of groundwater. RSA has begun planning waste diversion strategies on a national level through the Operation Waste Phakisa programme[92] and proactive provinces already promulgated organic waste landfill bans over the next 5-10 years. The president of RSA's recent state of nation address highlighted the country's plan for allowing municipalities and large energy users to purchase electricity from independent power producers (IPPs) within the next 12-18 months.

6.3.3 Market share

There is limited data with regards to the market which biogas holds within the waste treatment and energy mix markets due to the small and nascent nature of the biogas market. However, based on market intelligence gained through stakeholder engagements the total market size

[91] FACILITATION OF LARGE-SCALE UPTAKE OF ALTERNATIVE TRANSPORT FUELS IN SOUTH AFRICA – THE CASE FOR BIOGAS, commissioned by the Department of Environmental Affairs (DEA) in collaboration with the South African National Energy Development Institute (SANEDI) funded by the UK Department for International Development (DFID) through the Strategic Climate Policy Fund (SCPF) Programme

[92] Phakisa means "hurry up" in Sesotho. Operation Waste Phakisa is an initiative by national government to fast track the implementation of solutions on critical development issues under the National Development Plan (GreenCape, 2019).

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biogas projects previously identified is 43,800 kW of which 36.3% (15,886 kW) is in the C&I market.

At utility scale (i.e. above 10 MW), the REIPPPP has only awarded a single landfill gas project out of the 92 IPP projects awarded across the various technologies: solar PV (49%), oshore wind (37%), CSP (8%), hydro (3%), biomass (2%) and landfill gas (1%). ENER-G Systems was the project developer, owner, operate and installer of the country's first largest gas-to-power 18 MW project, spread across the five Johannesburg landfill gas sites as broken down in Table 33. The landfill sites are owned by the City Council of Johannesburg and share revenue with Eskom over the 20 years. Biogas market share growth and penetration has encountered barriers due to lower cost of electricity from other energy sources such as fossil fuels; lower efficiency of biogas compared to conventional fuels (Mukumba et al., 2016); lack of local technology providers introduces high capital cost implications for importing the technology and lack of awareness/skills from the sector.

Table 33: Landfill Gas-to-Energy project sites in Johannesburg

Landfill gas site	Expected waste (t/year)	Planned capacity (MW)
Robinson Deep	400 000	5.5
Marie Louise	530 000	6
Linbro Park	360 000	3.3
Ennerdale	90 000	0.5
Goud Koppies	270 000	3.3
		18

6.4 Customers and clients

The components for the biogas value chain within RSA can be seen depicted in Figure 35.

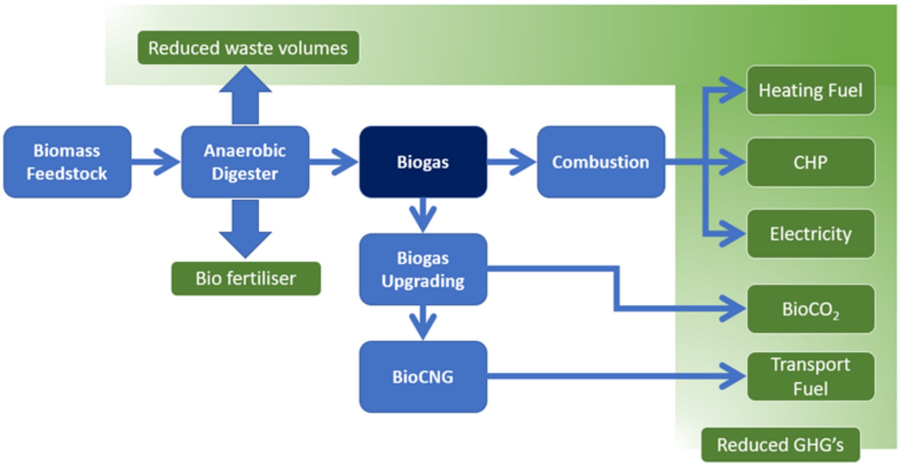

Figure 35: Components of biogas value chain[93]

[93] Overview of biogas site value chain depicted by Selectra (Pty) Ltd

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The customer and client value chain relationship for biogas projects and its components has been summarised in Table 34. The market segment dictates the feedstock generator and / or handlers (customers) as well as the potential client off takers with majority of proposed projects.[94]

Table 34: Biogas market segment and value chain (Customers and clients)

WASTE MANAGEMENT PHASES	Market Segment	Potential Feedstock	Potential Output
WASTE GENERATORS (CUSTOMERS)	1. Mining companies	Wastewater Treatment Works (WWTWs) sourced from their local communities	
	2. Metropolitan Municipalities/Local Municipalities	Municipal solid waste and WWTWs,	
	3. Fast Moving Consumer Goods, pharmaceutical companies	Organic solid waste, organic rich effluents	
	4. Agro-processors	Agricultural residues (also wastewater)	
WASTE HANDLERS (CUSTOMERS)	1. Private sector 2. Metropolitan Municipalities/Local Municipalities, WastePreneurs (small, micro, medium enterprises new to waste space) 3. Waste shredders	Organic waste from public and private sectors (dewatered sludge – considered liquid waste)	
UTILITY OFF-TAKERS (CLIENTS)	1. Local communities 2. Farmers 3. Mining companies 4. Manufacturing industries 5. Private sector 6. Transportation		Electricity, Heat, Bio-methane, compost (from processed sludge?)

6.4.1 Customer potential – Waste generators and handlers:

In 2017, South Africa generated approximately 108 million tons of solid waste, made up of 56 million tonnes of general waste and 52 million tonnes of hazardous waste. For general waste, 65.2% disposed to landfill, 34.5% was recycled and 0.1% treated.[95.] Disposal is the least fa-

[94] Based on stakeholder engagement with project developers

[95] Department of Environmental Affairs. (2018). South Africa State of Waste Report 2018 (Vol. 10, Issue 2)

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voured option within the waste management framework due to harmful effects to the environment and atmosphere. Domestic, commercial, business, and industrial waste in urban areas is disposed into landfill sites. Therefore, electricity generated from landfill sites can be distributed to neighbouring communities with minimal transmission losses.

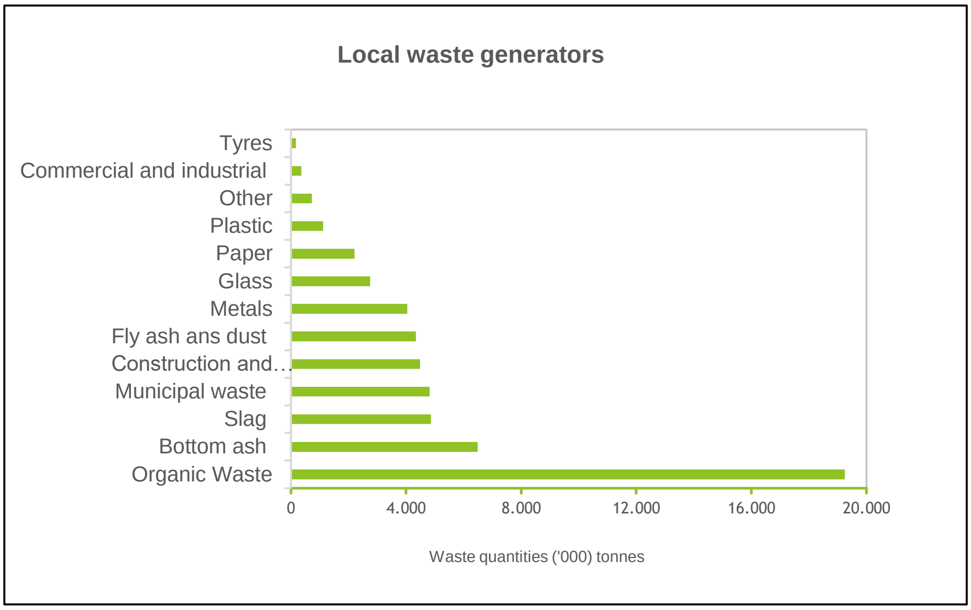

Figure 36: General waste generators (Department of Environmental Affairs, 2018)

An example of the customer potential within the LFG space can be seen in the LFG projects implemented in Gauteng. Gauteng's City of Johannesburg municipality initiated a carbon reduction project aimed at tackling excess methane emissions released from landfill sites; to control the air quality thresholds and convert the landfill gas to electricity for selling to Eskom through the REIPPPP. ENER-G Systems was rewarded the tender at an indexed 94 c/kWh to design, build, own and operate the five landfill sites. Three sites will be connected to the Eskom grid and two to the City Power's grid. ENER-G Systems is the only landfill developer with these REIPPPP projects.

City Power were prepared to purchase biogas electricity at a rate higher than the MEGAFLEX tariff, however ENER-G instead applied for REIPPP to sell power through the REIPPPP auction programme in which they received a better tariff. In order to fully assess the sector risks, we need to understand the tariff prices between Eskom, and the municipalities, and then municipalities to local consumers. The project indicators for the LFG to electricity project can be seen in Table 35.

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Table 35: Landfill Gas to Electricity project sites indicators

Projects Indicators	
Powered mid income households	25 000
Average output per MW installed	8 000 MWh/MW installed per year
Capacity factor	92%
Capital cost per MW installed	ZAR13.4 million
Operational cost per MW installed	ZAR 333/MW installed per month
Operational costs per MWh	ZAR 330 per MWh

6.4.2 Client potential – Energy off takers

Eskom, a state-owned electricity utility generates and sells over 90% of the electricity in South Africa; and supplies over 45% of the electricity used in Africa. The utility operates 16 power stations with total installed capacity of 44 172 MW, that generated 218 319 GWh during 2019 from the different sources of electricity (Eskom, 2019). Currently IPPs only sell electricity to Eskom.

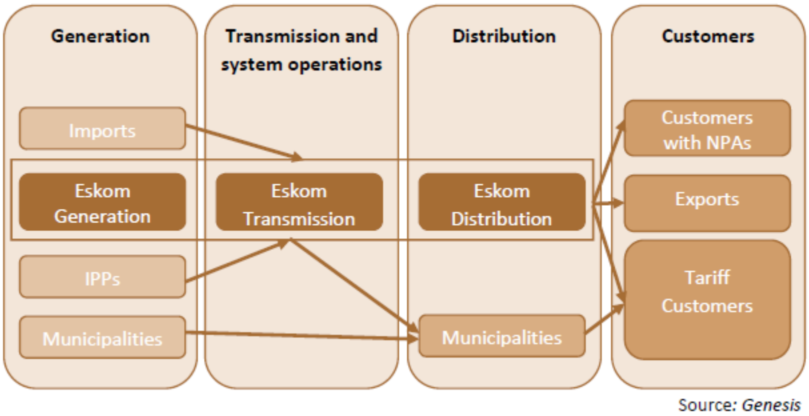

Figure 37: South Africa Electricity Supply Industry framework (Department of Public Enterprises, 2019)

Figure 37 shows the structure of the generation, distribution, and transmission units. It accurately illustrates the relationships among Eskom's units and other relevant parties such as customers with Negotiated Pricing Agreements (NPAs),[96] IPPs, municipalities, exports, and tariff customers. Additional electricity produced by stakeholders other than Eskom and the uptake thereof is guided by the Integrated Resource Plan and Renewable Energy Independent Power Procurement Producer Programme (REIPPPP).

6.4.2.1 Integrated Resource Plan

The Integrated Resource Plan (IRP) 2010 - 2030 is a long-term electricity generation plan that forecasts the country's electricity demand and procures energy sources to meet this demand

[96] Municipalities and businesses that have a high energy usage demand often negotiate a special pricing with energy supplier and/or regulators.

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based on the least cost tariff price. The plan allocates megawatts per technology and the implementation schedule that will supply and meet the country's forecasted energy demand. This process is promulgated by the Department of Mineral Resources and Energy (DMRE) and regulated by the National Energy Regulator of South Africa (NERSA) through Section 34(1)(a) of the Electricity Regulation Act, no 4 of 2006 (ERA).

6.4.2.2 Renewable Energy Independent Power Procurement Producer Programme

Renewable Energy Independent Power Procurement Producer Programme (REIPPPP) auction programme was created to support and achieve the country's target to generate 42% of its electricity from renewable energy technology sources by 2030 as variable source to supplement the baseload energy sources. In 2010, DMRE, National Treasury (NT) and Development Bank of Southern Africa (DBSA) established the Independent Power Producers Procurement Office (IPPPO) to delegate priority to the country's power generation capacity crisis. The IPPPO manages the REIPPPP auction programme where private sector independent power producers (IPPs) competitively bid to generate and source power from various renewable energy technologies such as solar PV, onshore wind, hydro, landfill gas and biomass.

An overview of the IPPPO procurement process and timelines can be seen in Figure 38 below.

Figure 38: IPPO Procurement process with an average 1.8 years lead time

An overview of renewable energy technology investment costs and average tariff offered can be seen in Table 36 and Table 37. The biomass technology highlighted in Table 37 refers lignocellulosic biomass, i.e. woody material.

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Table 36: Renewable energy technology investment costs

Technology	Procured (MW)	Total project spend (ZAR billion)	Avg. investment per MW procured (Million ZAR/MW)
Onshore Wind	3 388	80.6	24.0
Solar PV	2 292	65.9	28.0
CSP	600	58.4	97.0
Landfill gas	13	0.3	21.0
Hydro	19	1.1	59.0
Biomass	42	3.4	66.0

Table 37: Average technology tariffs offered, REIPPPP projects

Average technology tariff	R/kWh
Onshore wind	1.13
Solar PV	2.15
CSP	2.96
Hydro	1.55
Biomass	1.28
Landfill	1.88

6.4.2.3 Government guarantees

The IPPs compete on price tariff (70%) to be charged to Eskom and economic development contributions (30%) to local communities within 50km radius from project location. Preferred bidders sell power to single buyer Eskom; the national power utility over the 20-year PPA. National Treasury, Department of Public Enterprises and NERSA are the co-signatories to the Government Support Framework Agreement (GSFA) that underpins the Implementation Agreement (IA) between Eskom and national government; should Eskom defaults on its PPA payments to the IPPs. The IRP 2019 provides a breakdown of government guarantees with regards to renewable energy technology provisions (Table 38).

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Table 38: IRP 2019 renewable energy technology provisions

Technology	IRP 2019 Provisions by 2030 (MW)
Coal	1 500
Nuclear	1 860
Hydro	2 500
Storage	0
PV	6 000
Wind	14 400
CSP	0
GAS/Diesel	3 000
Other[97]	4 000

6.4.3 Biogas technology components suppliers

Local biogas technology companies remanufacture used technology to meet the original manufacturer standards, because the technology undergoes degradation due to the corrosive nature of the landfill gases, quality of the gases (poor gases damage the infrastructure more rapidly) and abrasive post-combustion residue. Therefore, local companies will opt to provide service exchange units for energy efficiency and maintenance purposes. Some of the most commonly manufactured parts include the valve-train components, connecting rods, crankshafts and cylinder blocks[98].

We observed that local technology components providers are predominantly smaller subsidiaries / agents to companies headquartered in European countries. In addition, local biogas technology companies act as the sales driver and technology distributors for the internationally head quartered companies. Our observation leads us to conclude that the biogas industry in South Africa is very immature, and it only makes a feasible business case to coordinate sales locally, rather than launching an entire manufacturing facility to a market with passive appetite to biogas technology.

6.5 Industry attractiveness (Porter's 5 Forces analysis)

A Porter's 5 forces analysis was completed to determine industry attractiveness of the South African biogas market for foreign and local stakeholders within the value chain.

6.5.1 Threat of New Entrants

The factors considered a threat for new entrants, who may include DiBiCoo companies, with regards to market accessibility wishing to enter the local market are listed below.

6.5.1.1 Barriers to entry

[97] The other technology category includes distributed generation, cogeneration, biomass, and landfill gas
[98] Engineering, M. A. (2019). Local remanufacture of gas engine components saves time, money. Metric Automative Engineering. https://www.metricauto.co.a/local-remanufacture-of-gas-engine-components-saves-time-money/

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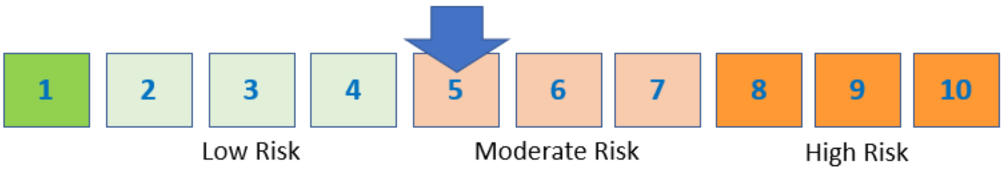
Economic & Political Outline

RSA is currently conducting an inquiry into allegations into state capture[99] as a means for dealing with and cleaning up a legacy of corruption and graft in both government and private sectors while Government's policies have not addressed the main structural problems such as high government debt at 59.9% of GDP with a debt service cost approaching 14% of revenues. Furthermore, public debt is expected to increase to 64.2% in 2020 and 67.9% in 2021. The ratings agencies have pictured South Africa in a downgrade cycle and South Africa could revert to junk status in upcoming rounds with political instability and associated unrest having created an unstable environment. External threats include arduous US trade policies and more recently the threat of the corona virus and the reduced local buying power with a declining Rand / Euro exchange rate will negatively impact imported goods.

In addition, the RSA renewable energy market already has high capital requirements and sunk costs related to market research, environmental impact assessments and non-refundable bid development costs estimated between R 10 to R30 million per bid. These costs have increased per bid window due to increased competitiveness observed through the programme's over-subscriptions in the bid window 3 to 4. The industry barriers encountered by new entrants are industry specific; however, exaggerated by the unsubstantiated regulatory delays enhanced the nascent renewable energy industry's perceived risk.



1 absolute zero risk **2** low risk **3** straightforward operational solution **4** require strategic adjustment **5** moderate risk **6** straightforward operational solution **7** require strategic adjustment **8** high risk **9** straightforward operational solution **10** require strategic adjustment

6.5.1.2 Institutional & Market Factors

These factors for South African biogas projects are summarised in Table 39.

[99] https://sastatecapture.org.za/

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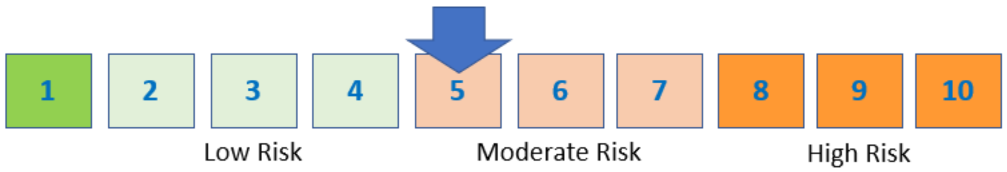
Table 39: Institutional and market factors identified

Factor	Remarks
Cheap Electricity	Current electricity supply is coal-based without costing in externalities. Competition from other renewables which yield lower cost electricity.
Limited subsidies & incentives	Initially a major factor in developing the European biogas industry.
Low-value waste	Government policy is to implement the “polluter pays principle” by increasing landfill gate fees, however fees will remain low to prevent illegal dumping. Current municipal tip fees range between free and R500 per tonne for general waste.
High capital cost	The cost of AD systems (including allied equipment) is beyond the reach of most farmers and small-medium companies.
High development cost	The cost of getting a project to Financial Close is between 12-18% of the total project. A large proportion of this cost is committed without any guarantees.
Long development time	Results in high holding costs and project fatigue.
Limited & high cost of funds	There are few local companies who readably finance biogas projects. Expected IRR’s are in the 25-30% range.
Bureaucratic roadblocks	Including; - Legislative process not streamlined - local, municipal, and national legislation not aligned as is specific legislation such as The Waste Act, OSH Act, prescripts by the energy regulator (NERSA) and others. - The Municipal Finance Management Act – ordinarily municipalities cannot contract in excess of 3 years without specific treasury approval. - Working with municipalities – lack of skills and a culture of excellence including willingness of individuals to conduct straight deals.
History of failed or less than successful systems	We have many failed or less than successful projects as references. - Most of the digesters at municipal wastewater treatment plants are hardly working. - Commercial examples include; o Kanhym Piggery – technology & waste stream analysis o Riverside Piggeries – turbines not supported locally as agent emigrated o Elgin – initially did not operate as envisaged design capacity due to overstatement of waste yields & plant capability o New Horizons plant in Cape Town – the IDC has recently issued an RFP for a local empowered company to take over the project.



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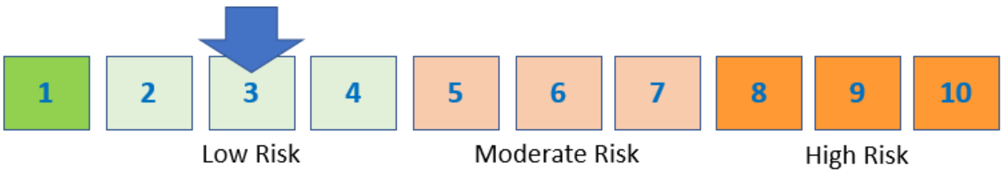
6.5.1.3 Economies of scale

Local project developers are attracted to the development of larger projects due to better ROIs and an insignificant development cost and time difference between small, medium and large projects. This has resulted in project developers focusing on niche markets in which their expertise allows them to excel. Examples of these can be seen in the abattoir, breweries and poultry sectors.

One project developer has developed several abattoir projects, which have allowed them to amortise market development costs and "school fees" for future projects thus giving them an advantage in the market. Similarly, another project developer has partnered with one of RSA's largest brewery businesses to supply a standard solution to all their breweries within South Africa.

Most industrial applications require bespoke solutions due to the high degree of concentration. For example, South Africa has only two large breweries and many small craft breweries. Installing imported biogas systems at the craft breweries may not be feasible and if feasible, the business case could be prohibitive.

The chicken broiler and layer industries are potential growth markets that could benefit from economies of scale, as the industry is served by many Independent contract farmers. However, a demonstration site will be necessary to develop this market segment.



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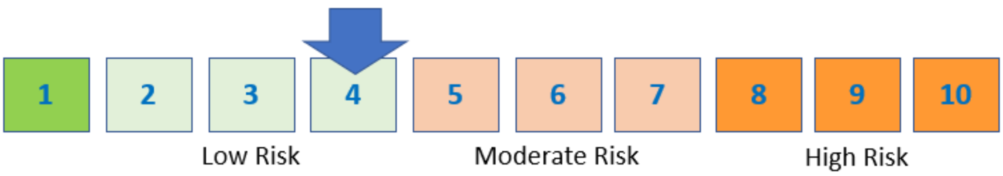
6.5.1.4 Brand loyalty

The local market is served by solution providers who have reference projects to use in marketing. However, in most cases, the local companies have international technology partners who support their market activities and underwrite their technology. New market entrants are unlikely to do well without the support of a reputable South African partner and finding these new partners may be difficult.



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6.5.1.5 Capital requirements

The long development lead time, high RSA Rand cost of equipment, and long project payback is a major deterrent for new market entrants. The ideal timeline for biogas project development in RSA is highlighted in Figure 39 and Table 40 below.

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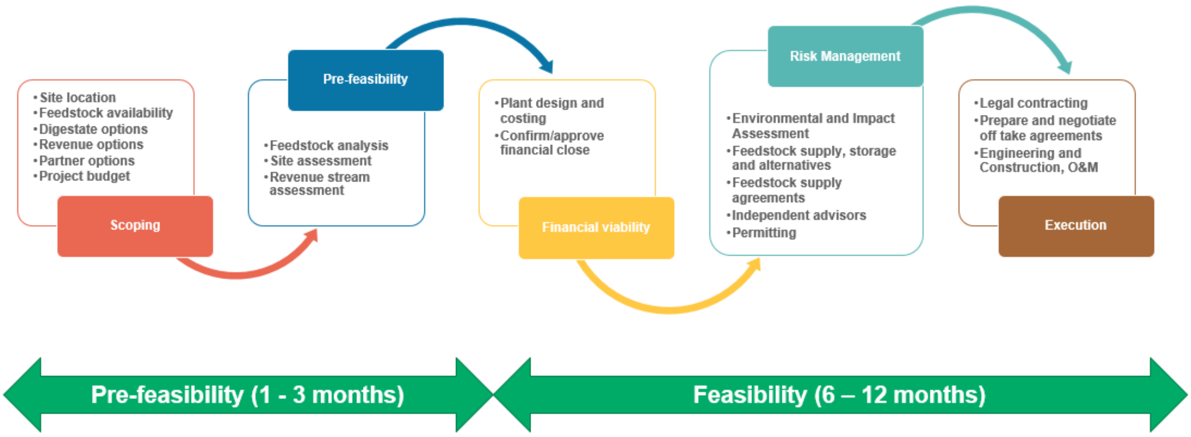

Figure 39: The overview feasibility of a biogas project development[100]

Figure 39 outlines the pre-feasibility and feasibility steps taken before a project can process to the project development phase as outlined in Table 40.

Table 40: Biogas project development guidelines[101]

Project development phase	Duration
Financial close	**1 - 6 months**
Commitment to capital and build	
Conclusion of contracts (offtake, EPC, feedstock, O&M, digestate, SPV)	
Construction	**6 - 12 months**
Lead contractor management	
Owners engineer, lenders technical advisor	
Commissioning	**6 -12 months**
6 - 12 months commissioning	
Operations and maintenance	**24 months**
Two-year EPC management and training – performance guarantee	

Typically, it can take 3-5 years to develop a biogas project, however existing projects that have been developed show that the development lead time are longer than the ideal timelines mostly as a result of environmental permitting and allied licensing (it takes 12-18 months to conduct an EIA). In addition, funding and structuring is challenging as working with institutions and development banks is time consuming.

The project development timeline for the Bronkhorstspruit Biogas Project, South Africa's first commercial AD project, is depicted below.

[100] GreenCape. (2018). Biogas project development life cycle.
[101] GreenCape. (2018). Biogas project development life cycle.

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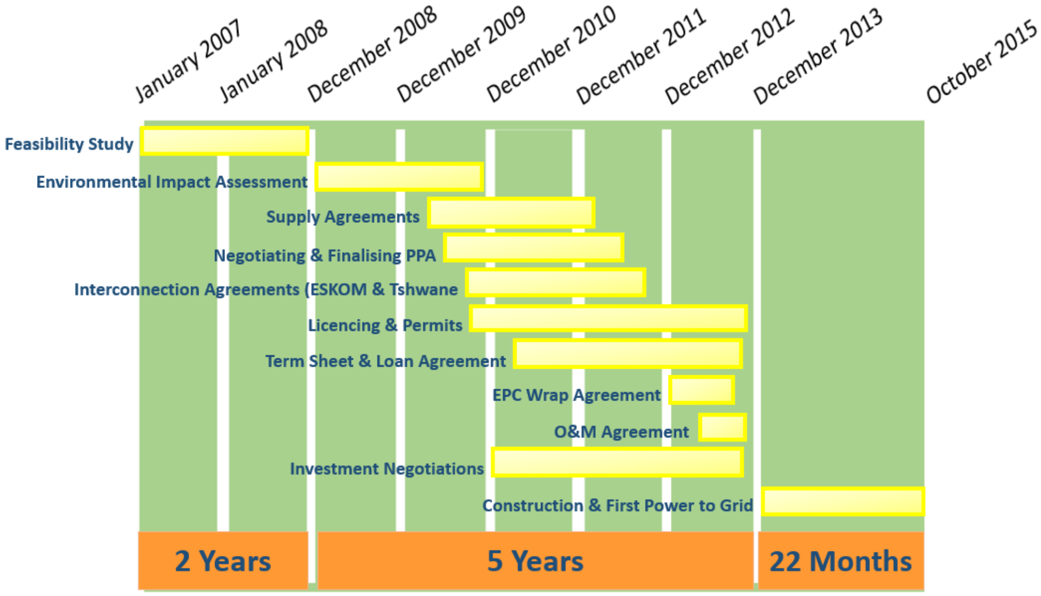

Figure 40: Bronkhorstspruit Biogas Project development timeline[102]

Bio2Watt's project development timeline has been reduced after gaining experience from doing the Bronkhorstspruit Biogas Project as shown below.

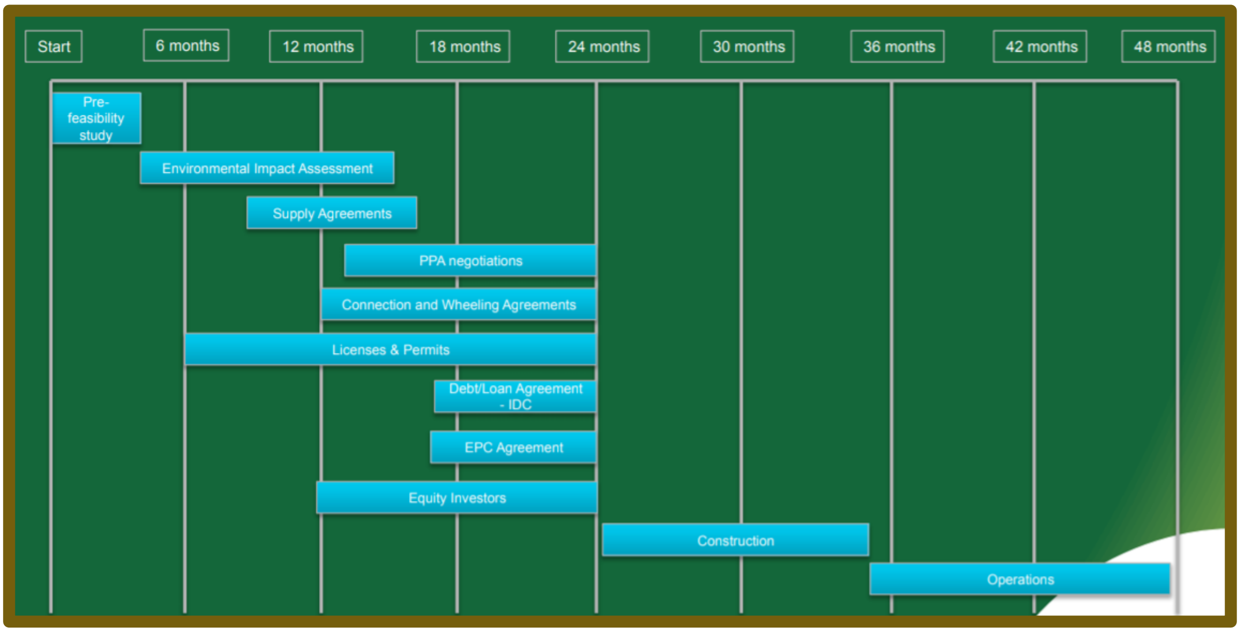

Figure 41: Updated biogas project development timeline[103]

The global biogas equipment suppliers commonly partner with local sales agents; for business development and cost-effective market entry purposes. These agents work for/with major foreign technology suppliers and this has massive cost implications and is affected by the foreign

[102] Adapted from Presentation IMPLEMENTING A BIOGAS PROJECT IN SOUTH AFRICA: LESSONS LEARNT, Bio2Watt, January 2014
[103] Presentation BIOGAS PROJECT: LARGE SCALE MIXED WASTE AD SYSTEM, Bio2Watt, February 2015

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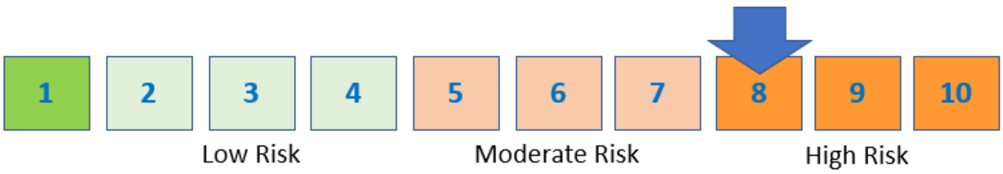
exchange fluctuations. The cost of the equipment is informed by the design of the digester, type of energy infrastructure and the size of the infrastructure and prone to foreign exchange.

The cost of large-size biogas plants is around Euro3.5m per MWe[104] or R70m at current exchange rate (€1 = R20). A rate of R1.25/kWh is required just to recover the capital cost over 15 years. This rate, which is significantly above the utility rate excludes OPEX and generation costs.

Typically, the biogas project payback period within the SA market ranges between 5 – 8 years. The payback period is the time taken for a project's net cash flows to recover project's initial investment. Commonly, biogas projects report payback period of 7.62 years deems the biogas project economically unviable. However, the discounted payback period where the cash flows are firstly discounted before the payback period is calculated, deems biogas project economically viable. Discounted payback period is superior to payback period; and subsequently we regard biogas project as suggested.



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6.5.1.6 Government policies

Current government policies are viewed as a major barrier for new market entrants. AltGen Consulting of 105 list 29 policies, legislature and framework upholding the green economy in RSA.

The basic requirements to develop a biogas project[106] are listed in the columns below:

Table 41: Biogas project legislative requirements breakdown

1. Energy and Environmental Policies ○ Renewable energy policies ○ Climate change policies ○ Agriculture policies ○ Waste policies ○ Natural gas policies **2. Socio / Political** ○ Government procurement policies ○ Broad-Based Black Economic Empowerment (BBBEE) ○ Employment Equity	**3. Economic and Financial Policies** ○ Feed-in tariffs ○ Grants / soft loans ○ Exchange control **4. Research and Development** ○ Coordinated (large-scale) R&D programmes **5. Other Support Schemes** ○ Long-term government planning documents ○ Partnerships between the public and private sectors
6. National Environmental Management Act (NEMA) Act 107 of 1998	

[104] Based on aggregated pricing obtained through stakeholder engagements with existing project developers and owners.

[105] Biogas Industry In South Africa: An Assessment Of The Skills Need And Estimation Of The Job Potential, AltGen Consulting for Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and South African-German Energy Programme (SAGEN), https://www.sagen.org.za/publications/19-assessment-of-skills-needs-and-estimation-of-the-job-potential-for-the-biogas-industry-in-south-africa/file

[106] Eddie Cook, SABIA

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- Overarching environmental legislation which provides for Special Environmental Management Acts (SEMA's)
- Listed activities with thresholds which determine if authorisation is required
- Enabling legislation for EMPr, Audits, Appeals
- National Environmental Management Waste Act (NEM: WA) – Waste Management License
- National Environmental Management: Air Quality Act (NEM: AQA) – Atmospheric Emissions License (currently being relaxed)
- National Environmental Management: Biodiversity Act (NEM:BA) - Permit
- National Environmental Management: Protected Areas Act (NEM: PAA) – Environmental Authorisation

7. National Authority

- Waste Management License (hazardous waste)
- Environmental Authorisation for generation of electricity
- Water Use License (digestate, irrigation)
- Gas Registration
- Heritage

8. Provincial Authority

- Waste Management License (general waste)
- Environmental Authorisation
- Heritage
- Local Authority
- Air Emissions License (District Municipality)
- Planning permissions

9. Other legislation to comply with

- National Water Act
- National Heritage Resources Act
- Agriculture (SALA, CARA, Fertiliser Act)
- Planning (SPLUMA)
- Civil Aviation

10. Minimum Requirements

- National Gas Act
- Municipal planning laws
- Building regulations
- Engineering and design
- Site and zoning approvals
- Fire and safety approvals
- Environmental and waste approvals
- Installation and commissioning approvals
- Operational and trading approvals
- Recertification and periodic inspections

Progress has been made from government departments: Department of Mineral Resources and Energy (DMRE) and the Department of Environment, Forestry and Fisheries (DEFF) to support the industry. Within the government sector, DMRE is the largest most influential core stakeholder because they have direct authority over anything related to energy development. The DMRE is the primary authority for policy and legislation in the energy sector within South Africa. They have the authority to declare the conditions to generate, distribute and trade electricity. The sheer number of Acts and policies to comply with can act as a disincentive to new market entrants.

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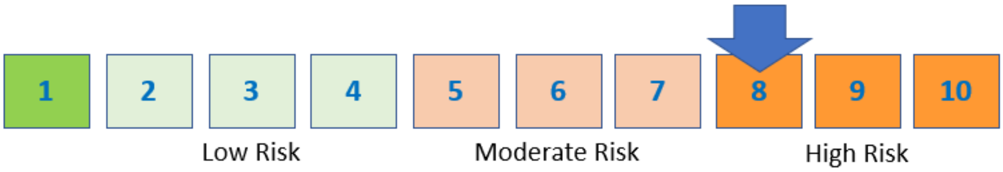

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6.5.2 Bargaining Power of Buyers

There is a large degree of specialisation amongst the biogas project developers within RSA. A non-exhausted list with a few examples of active stakeholders and the feedstock used within their projects developed within RSA can be found below:

- Agama – rural & household
- Bio2Watt – cattle manure
- Fountain Green Energy – landfill gas
- Green Create – poultry abattoir/processing
- Ibert - livestock abattoirs
- Talbot & Talbot – brewery applications
- Veolia – wastewater treatment

This demonstrates that there is broad spectrum of opportunities for biogas project development within RSA.

6.5.2.1 Number of customers

In the past there were a limited number of local companies developing a limited number of biogas projects. In Appendix 1 we list the major solution providers (developers & technology providers) and their projects. The list contains 19 solution providers across 46 projects / installations as shown in Table 42.

Table 42: Number of projects in relation to number of solution providers

Project Category (number of projects completed)	Solution Provider by Project Category	Total Projects
1	10	10
2	3	6
3	2	6
4	2	8
5+	2	10
	19 Solution Providers	46 Total Project Analysed

Agama and small biogas projects have been excluded in the above analysis as this category is unlikely to be a customer for DiBiCoo.

The above table shows that most solution providers have completed only one project – 10 projects by 10 solution providers. Three solution providers have each completed two projects; two solution providers have each completed three and four projects. The maximum number of projects completed by a solution provider is 10 projects.

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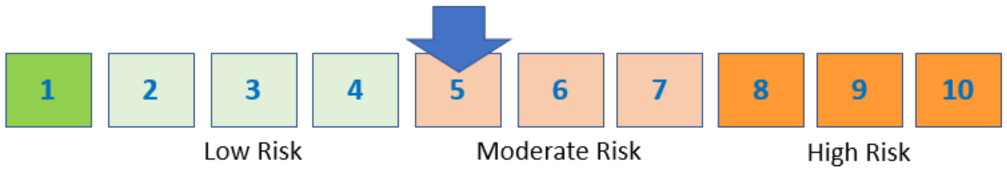
Our market research indicates that there are more than 45 companies in RSA promoting AD Biogas technologies within the country, most of which are project developers / engineering companies and specialist equipment suppliers.

6.5.2.2 Size of each customer order

Obtaining project costs and making comparisons is not easy and fraught with danger as developers do not readily share this information. We estimate the cost range for new builds sized between 12.5kW to 4,6MW to be ZAR40 million per MW. But this is highly dependent on the feedstock and other processing requirements. The following project costs (Table 43) have been disclosed through previous desktop studies conducted.

Table 43: Project costs breakdown

Project	Cost	Details
Zandam	R8.5m	500m^3, 75kWe, 105kWt
Uilenkraal	R11m	7,000m^3, 500kVA
New Horizons	R400m	760Nm^3/h BioCNG 18 t/d food grade CO2
Elgin	R20m	500kW



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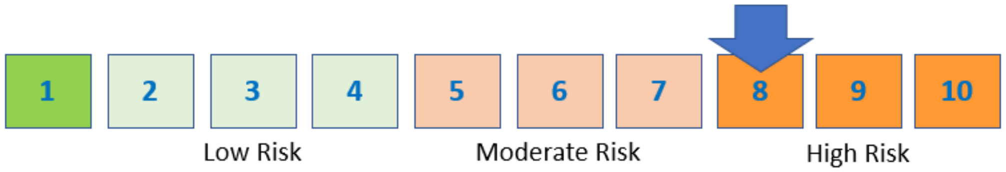
6.5.2.3 Buyers costs

It takes between 3-5 years to develop a biogas project from start of initial project scoping to financial close in RSA. The long lead time item is the Environmental Impact Assessment which takes between 12-18 months to complete. The total cost of developing a biogas project typically ranges between R2m to R7m with about half at risk if the project is not completed.



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6.5.3 Threat of Substitute Products

There are very definite applications where biogas has an opportunity to sustainable substitute other technologies / fuels.

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6.5.3.1 Number of substitute products

The substitute products are relative to the primary and secondary functions of the biogas system. A list of substitute products, product market competitors and motivation for biogas products can be seen in Table 44.

Table 44: Products which biogas projects may substitute

Product / Service	Market competitor	Motivation for biogas
Transportation fuel	petrol, diesel and lately electric	Lower cost green fuel, good for the environment.
Wastewater treatment	aerobic digestion vs anaerobic digestion	Aerobic digestion is energy intensive, while AD yields energy-rich biogas while reducing sludge volumes.
Electricity production	coal, diesel power generation	Reduction in GHG emissions, cheaper than diesel power generation.
Renewable electricity	wind, solar, hydrogen fuel cells and hydro	Only viable in special circumstances
Solid waste treatment	composting and thermal treatments	Sustainable way to treat organics

Current commodity prices are very supportive of using biogas in transport applications as market intelligence indicates that BioCNG can be sold for R140 – R180/GJ (UNIDO, 2018). At this price BioCNG is an economic substitute for paraffin, LPG, diesel and natural gas used in heating applications as shown in Table 45 and can be considered almost comparable with natural gas in terms of pricing.

Table 45: Commodity price comparison[107]

Commodity	Price	
Parafin	R233	R/GJ
LPG	R396	R/GJ
Electricity	R214	R/GJ
Natural gas	R160	R/GJ
Diesel	R349	R/GJ
Solid Fuel	R28	R/GJ
Charcoal	R120	R/GJ
Coal	R31	R/GJ

Electricity generated from biogas cannot compete on price only with regards to utility scale electricity produced from coal as well as other renewable energies. The cost of biogas electricity is in the region of R 1.40-R1.50 per kWh with free issue of feedstock. This is about twice the IPP tariff (Bid Window 4, expedited) for Solar PV (R 0.62) and Wind (R 0.62).

[107] Calculations completed and compiled by Selectra (Pty) Ltd

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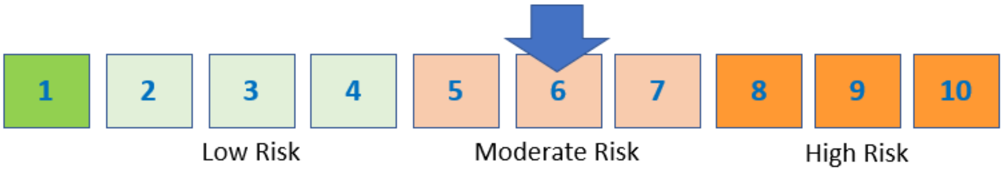


1 absolute zero risk **2** low risk **3** straightforward operational solution **4** require strategic adjustment **5** moderate risk **6** straightforward operational solution **7** require strategic adjustment **8** high risk **9** straightforward operational solution **10** require strategic adjustment

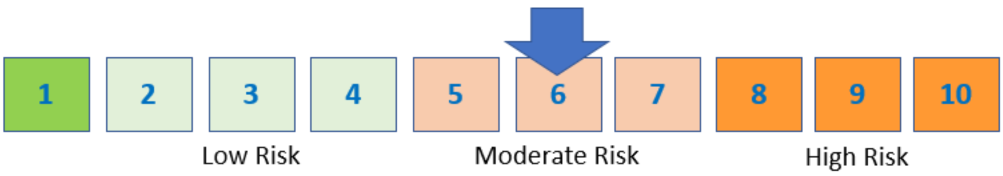
6.5.3.2 Buyer propensity to substitute

Buyers normally have a choice of technologies and suppliers of these technologies. However, there are several failed or underperforming biogas projects in RSA. Buyers are therefore less likely to shop around once a track record and strong relationship has been formed.

In addition, in the utility scale renewable energy landscape biogas is one of the under allocated clean energy sources within the national energy mix plan, IRP; with only 0.5% procured clean energy technology providers; as shown in Table 46. The renewable energy industry breakdown does not currently favour biogas. Therefore, lack of biogas regulatory framework to catalyse the growth of the industry significantly limits the possibility for technology buyers to substitute. In addition, this industry is highly specialised and biogas technology providers for specific end user are limited.

Table 46: The REIPPPP breakdown of the renewable energy sources

Pro-grammes	Large IPP			Small Scale IPP		
Technology	**Procured**	**Opera-tional**	**Deter-mined**	**Procured**	**Opera-tional**	**Determined**
Wind	3 357	1 980	6 360	9	0	400
Solar PV	2 292	1 474	6 225	80		
Concen-trated solar power	600	500	1 200	0		
Landfill gas	13	22	540	0		
Small hydro	19			0		
Biomass	42			10		
Total	**6 323**	**3 976**	**14 325**	**99**	**0**	**400**



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6.5.3.3 Relative price performance of substitute

In section 6.5.3.1, the relative fuel costs have been noted. CSIR demonstrates (Figure 42) that biogas electricity is on a par with mid-merit coal (a power plant that adjusts its power output as demand for electricity fluctuates throughout the day).

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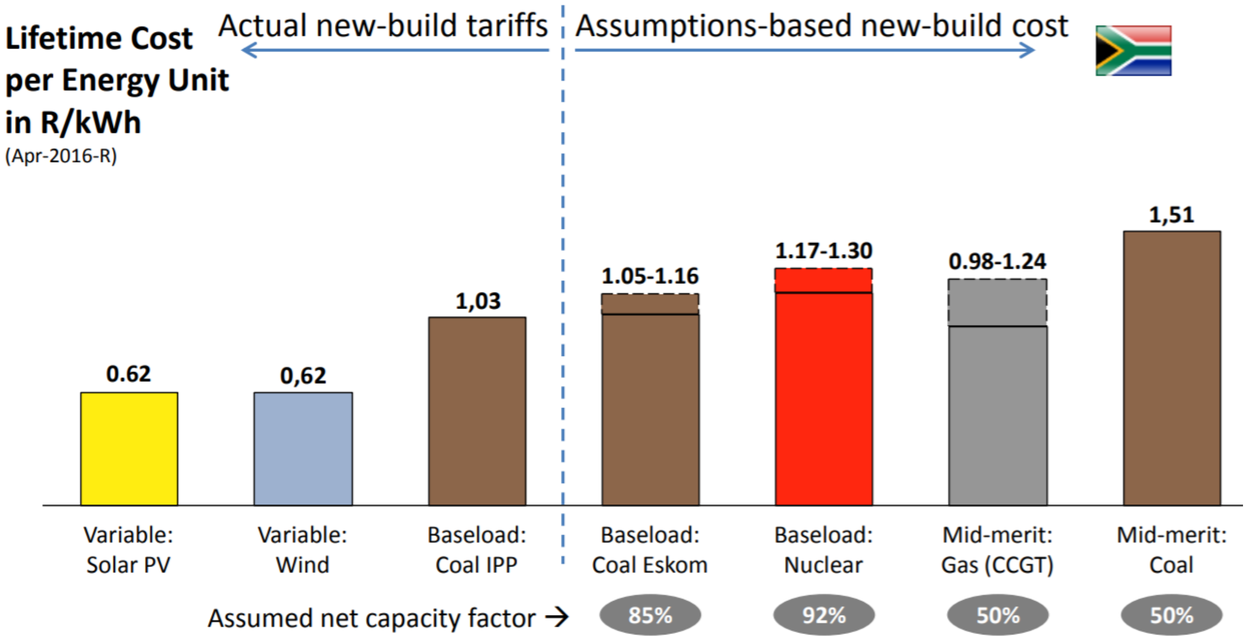
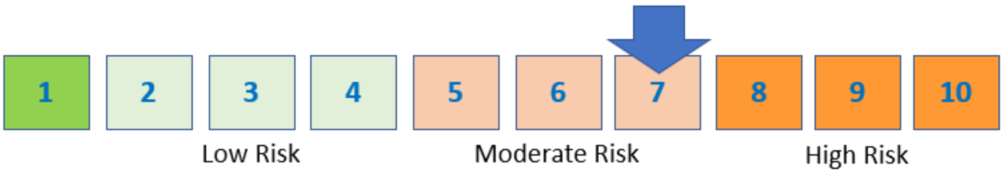


Figure 42: Lifetime cost per energy unit in R/kWh[108]

The CAPEX cost of a biogas electricity generating plant is four times that of an equivalent PV plant although a 100kW biogas will produce 2,250kWh/day compared to a 100kW solar plant that only produces 500kWh/day.



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6.5.4 Bargaining Power of Suppliers

The local biogas market is small with probably less than 5 large projects per year.

6.5.4.1 Number and size of suppliers

Most of the local biogas technology and equipment providers are contracted to overseas suppliers which are predominantly European companies. New locally based market entrants will look to partnering with technology suppliers who are not active in the local market.

In section 6.5.2.1, it was noted that market research indicated more than 45 companies in RSA promoting AD Biogas technologies, most of which are project developers / engineering companies and specialist equipment suppliers.

Typically, these companies range from;

- Small company (less than 10 staff) offering small-scale solutions for households up to rural communities, the exception being Agama who is a medium sized company.

[108] CSIR Energy Centre presentation, 14 October 2016, https://www.csir.co.za/sites/default/files/Documents/WindAC_LCOE_bofinger.pdf

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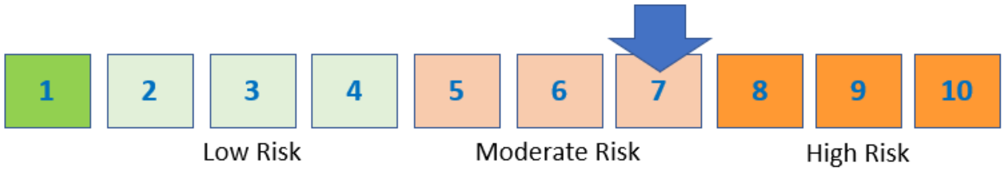
- Small/medium company doing medium sized projects up to 1MW.
- Large companies doing large projects – good examples are Veolia and Talbot & Talbot.



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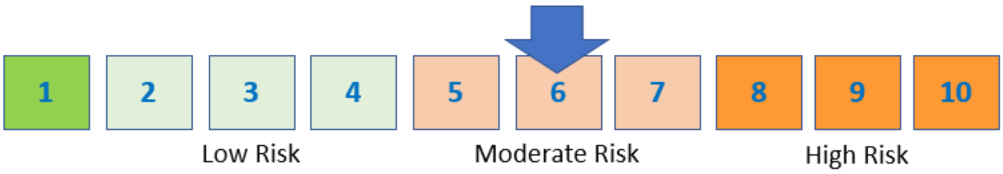
6.5.4.2 Uniqueness of each supplier's product

The biggest differentiation for the uniqueness in supplier product can be determined in the quality versus price relationship. In RSA, the perception is that European suppliers trade on superior technological solutions predominantly for mature markets with skilled personal whilst in contrast, suppliers from the East primarily tend to trade on price. This can be seen in the completed projects which suggest that the South African market is more quality conscious although less costly lower quality systems have found a foothold.



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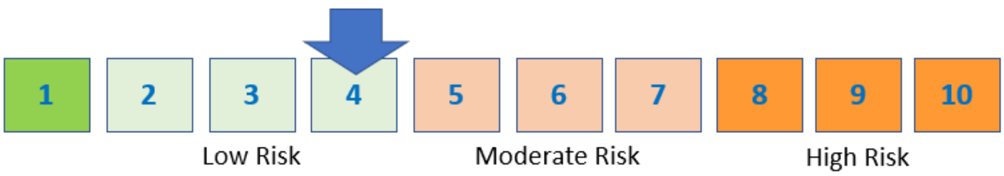
6.5.5 Rivalry Among Existing Competitors

The local market is very competitive, with a large number of project developers competing for a very small number of projects (fewer than 5 large projects reach financial closure per year). Projects have high capital cost coupled with long return of investment which results in customer scrutiny. Project developers who have reference sites have a distinct advantage as customers want to see proof of concept and successful local application. The credibility of visiting sites on other continents has been reduced due of past failures or underperforming systems unable to adapt to local conditions.

Competition is also expected from traditional air separation companies. Afrox (a member of the Linde Group) supported the New Horizon project in Cape Town by supplying and funding. The Linde built the world's largest plant for converting landfill gas into eco-friendly biogas.



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6.6 Competitive analysis

6.6.1 Competition overview

The European biogas systems and OEM markets may have reached maturity, however the South African biogas market, in common with other developing countries, is a growth market entering the Mainstream Market stage. RSA is moving past the innovation and early adopters' stages and hence qualitative differentiation and focused market/application strategies become important to insure continued growth and maturity as demonstrated in Figure 33 previously.

Competition, to a large extent, from both the energy and waste management dictates and informs the existing and developing marketing programmes for biogas projects.

6.6.2 Direct competitors

A total of 39 stakeholders promoting biogas technologies were identified within the stakeholder mapping study for RSA. These 39 stakeholders include combination local technology suppliers, project developers, EPCs and owner's engineers. These local stakeholders represent the direct competition within the biogas market as they all compete for the available feedstock resources generated by the customers, viz. waste generators and handlers, highlighted in Section 6.4 and Table 34. The customer needs provide insight to technological requirements. Some of these needs are highlighted in the SWOT analysis of potential sites suitable for biogas projects in Table 47 below.

Table 47: SWOT analysis of potential sites

Customer sector	Strengths	Weaknesses	Opportunities	Threats
Sugar Estates	Produce large quantities of digestible material in waste stream Most? have sufficient space for a digester Ability to be a self-off taker	Worldwide over supply of sugar, industry in decline Combustion least cost way to extract value from straw & bagasse	Vinasse & filter cake have high potential for biogas Opportunity to produce high value vehicle fuel – convert transport fleet to duel fuel Industry looking for ways to reduce costs / increase sales Could be the future food & fuel farm	Government's land redistribution policy Largest local producer in severe financial difficulty – market and corporate malefice
Dairy farms	Well established dairy industry Eastern & Western Cape has large number of farms Industry has reference sites Farms already have open lagoons for low-tech conversion	Few TMR dairies, most cows not in barns resulting in reduced collectable manure volumes High production costs in relation to selling prices	Eastern Cape has high electricity costs and poor electricity supply from inept municipalities Energy required for heating & cooling	Government's land redistribution policy Located in prime areas High concentration of major dairy farms

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Piggeries	Large number of intensive farms with pigs in barns High biogas potential Open lagoons SOP Has successful reference sites	Cost of producing electricity from biogas Not big energy users unless have an on-farm abattoir as in the case of Riverside Piggery Has unsuccessful reference sites Heating lagoons during cold winters	Farms require upgraded waste treatment solution to meet current & future environmental standards	Government's land redistribution policy
Broiler farms	Large number of commercial farms with chickens in climate-controlled houses Commercial farm will have at least 4 x 6 houses with 30,000 broilers/house	Some bedding material not suitable for digestion[109] May need organic material to adjust C:N ratio Difficult to digest Houses cleaned out after 35 days Costly to replace coal heaters	Need to look at export customers as waste can produce 2-3 times farm's energy requirement Good way to reduce carbon footprint	Government's land redistribution policy Litter sold to feedlots (illegal) and fertilizer producers Biosecurity – need to remove litter from farm
Layer poultry farms	High production farms Litter normally removed daily No bedding material	May need organic material to adjust C:N ratio Difficult to digest Good fertiliser material	Opportunity to produce high value vehicle fuel – convert transport fleet to duel fuel Good way to reduce carbon footprint	Government's land redistribution policy Big move to "free range" Litter sold to feedlots (illegal) and fertilizer producers Biosecurity – need to remove litter from farm
WWTW	Continuous and consistent supply of organic waste Industry familiar with /acceptance of treatment method – not new	Low organic loading of wastewater Many sites not operating near capacity, if at all Shortage of skilled operational personnel	Produces energy-rich biogas Good way to reduce production costs while increasing capacity Government's support of PPP's for implementation	New high capacity, low sludge producing and low-energy wastewater treatment technologies

[109] Most bedding used consists of lignocellosic (woody) material not suitable for anaerobic digestors

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	Aerobic treatment is energy intensive Large volumes, and with population increase volumes will increase	Availability of land at the treatment works		

6.6.3 Indirect competitors

The indirect competition to the stakeholders that deliver and implement biogas projects can be divided into the following sectors, viz. waste, energy and water.

Within the waste sector the largest competitors for biogas are waste handlers and municipalities. Waste handlers include the 6 major waste management service companies within RSA. These waste management service companies provide services to both the C&I sector and municipalities. Municipalities are mandated by legislation to collect and dispose of waste from residential areas and expanded services to the C&I sector. The municipalities would often outsource these services to waste management companies. These indirect competitors can be converted into customers through collaboration.

The demand for energy within RSA provides insight to the indirect competitors to biogas and its clients highlighted in Table 34. A large portion of these competitors are found in the renewable energy technologies space, but it does not exclude Eskom. The current legislation and policies and the cost of biogas compared to other renewable energy technologies make it difficult for biogas to compete with other energy sources such as solar, wind and coal within RSA as has been highlighted in section 6.5.3.

6.6.4 Potential competitors

Other potential competitors include the following stakeholders/sectors:

- Composting – Compost manufacturers often compete directly for feedstock and provide a lower cost solution to feedstock generators.
- Black soldier fly farms – Similar to composting, this technology competes for the same feedstock to produce a raw feed protein alternative for animal feed.
- Water treatment – There are a number of alternative water treatment technologies such as membrane separation, chemical and mechanical treatments.
- Piggeries – Smaller pig farms would often compete for the same feedstock as biogas which they would use as a feed to their pigs.
- Electric vehicles – With the increase growth of the electric vehicle market, it provides competition to the development of biogas being used as an alternative fuel in RSA.
- Other renewable energy technologies – The growth of renewable energy technologies such as solar PV and wind in RSA has been more rapid as these projects have lower CAPEX and are not as complex thus carrying lower risk for investors.

6.7 Market policies and incentives

RSA has three tiers of government: National, Provincial and Local. Broadly speaking, National Government is responsible for drafting of legislation (and enforcement thereof); Provincial Government has the same responsibilities as National Government, but on a Provincial level, with

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local government having the primary role of implementers. This is illustrated in Figure 43 and Figure 44.

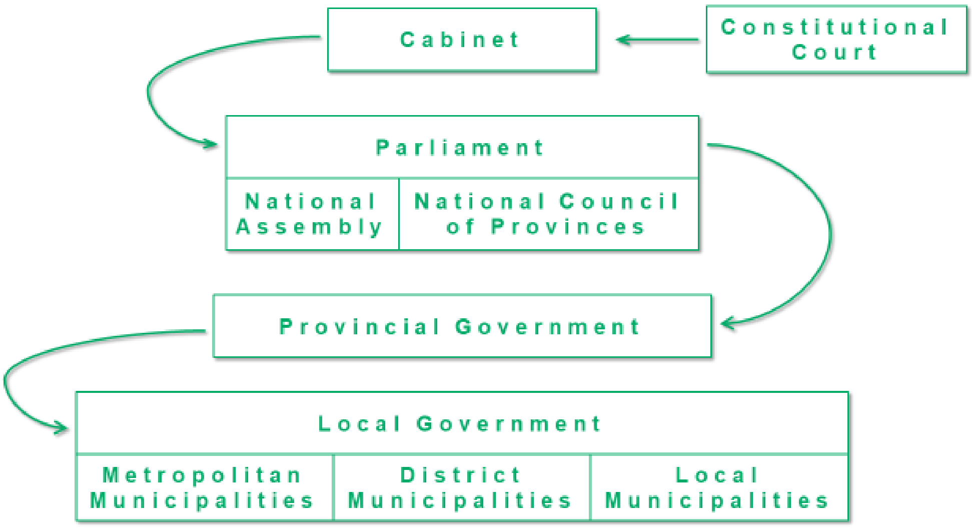

Figure 43: Tiers of government

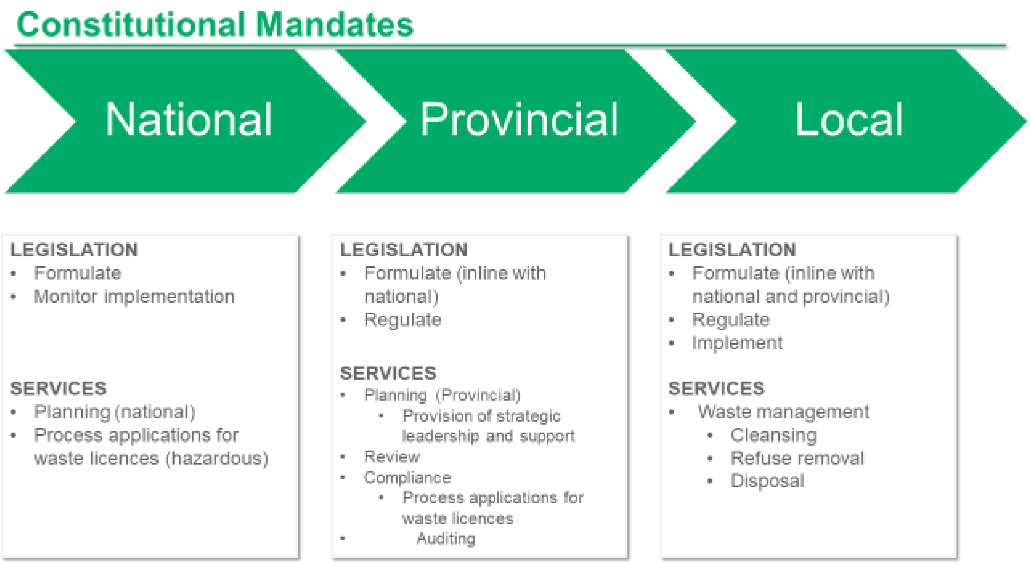

Figure 44: Constitutional mandates of branches of government

6.7.1 Government legislation and policies

The following legislation and considerations may be applicable to the development and implementation of a biogas project:

- National Environmental Management (NEM) Act - GN 983, 984 and 985
- National Environmental Management: Waste Act - GN921
- National Environmental Management: Air Quality Act - GN248
- Biodiversity consents (National Forest Act, NEM: Biodiversity Act, NEM: Protected Areas Act, Outeniqua Sensitive Coastal Areas, Integrated Coastal Management Act)
- National Water Act - Water Use License

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- National Heritage Resources Act
- Agricultural Consents & Regulations (Subdivision of Agricultural Land Act, Conservation of Agricultural Resources Act, Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act)
- Land Use Planning – Rezoning or subdivision
- Civil Aviation Authority – Height of facility and location within the vicinity of an airfield, airport or aerodrome

The NEM acts highlight the requirements a project would need to address in terms of its environmental impacts. The biodiversity consents and National Heritage Resources Act ensure that a project has considered the impacts it may have on the local ecosystems and resources. The National Water Act considers the water usage and efficiency implications of the project. Agricultural consents and regulations may impact the feedstock and digestate of a project. The land use and civil aviation considers the logistical side on the project location and its implications. These considerations are applicable to all biogas projects. A breakdown of the basic requirements to develop a biogas project can be found in section 6.5.1.6.

6.7.2 Other incomes

Other incomes, incentives and policies that may not be considered as the primary focus for the business case for biogas projects but may make it more attractive include:

- Carbon Tax Act – A tax rate of 120 ZAR/tCO2e for direct emissions at large industrial emitters (annual increase of CPI plus 2%). This means that businesses are motivated to reduce their direct emissions.
- Small scale embedded generation (SSEG) feed in tariffs – Certain municipalities offer feed in tariffs to projects up to 1MW scale provided those projects are net users of the electricity generated.

6.8 Resources

It is important to identify the natural, human and proximity resources available within a region or country to understand the support mechanisms as well as risks that may influence the development of a biogas project. A number of research studies have been conducted to identify the available resources.

6.8.1 Natural resources

South Africa is rich in natural resources suitable for usage as feedstock within biogas plants. The Bio-Energy Atlas (Hugo, 2016) published by the Department of Science and Technology provide an overview of the potential of bioenergy materials across RSA which are suitable to be used as feedstock for biogas projects. Table 48 shows the available feedstock that could be used to feed a biogas plant.

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Table 48: Availability of feedstock for energy applications (Hugo, 2016)

Source	Potential (dry mass) Million Tonnes/yr.	Available now (dry mass) Million Tonnes/yr	Energy equivalent available now (GWh/yr)
Agricultural residues	36.22	5.80	16 097
Sugar cane bagasse	5.35	0.60	1 672
Pulp and paper mill residues	0.69	0.01	25
Organic solid waste component	6.47	5.82	16 175
Organic sewage sludge	2.53	2.28	6 325
Purposely cultivated crops	9.26	9.26	37 811
Total	60.52	23.77	78 105

For the agricultural residues highlighted in Table 48 above has a relaxed assumption that 50% more agricultural residues can be extracted above a conservative extraction rate of these residues. This safe assumption means that the availability of agricultural residues could be increased in practical implementation. All sugar cane bagasse and pulp and paper resources are currently used for low-efficiency energy generation. It would be possible to improve the efficiency of energy generation from 33% to 50% through capital investment in new technology, however both of these industries are currently in decline which may reduce the feedstock amounts available. Both the organic fraction of domestic solid waste and organic sewage sludge highlighted were reported as the total available, minus an estimated 10% that is currently used for composting, electricity generation or biogas manufacture. The purposely cultivated crops were highlighted for the best available options in respect of feedstock, however, may not be feasible to process on techno-economic grounds as the stated amount takes only subsistence farmland into account. However, RSA has limited arable land and legislation and policies dictate that this land must be used for food production. Therefore, purposely cultivated crops only hold potential for biogas if the crops are grown on land that needs to be rehabilitated.

Additional studies include GIZ (2016c) and GIZ (2016b) which estimated the distribution of the potential of biogas production for electricity generation from agro-waste sectors and WWTWs. Table 49 and Table 50 highlighted the estimated potential of livestock wastes as well as abattoir wastes.

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Table 49: Livestock manure quantities and methane production capacity potential (GIZ, 2016c)

Province	Total cattle solid manure production (Million tonnes/yr)	Expected methane production (m³/yr)	Total cattle liquid manure production (Million tonnes/yr)	Expected methane production (m³/yr)	Total pig manure production (Million tonnes/yr)	Expected methane production (m³/yr)	Total poultry manure production (Million tonnes/yr)	Expected methane production (m³/yr)
Eastern Cape	98,0	5 194 000	3 425,1	58 227 142	73,8	885 504	158,6	13 163 828
Free State	336,0	17 808 000	780,6	13 270 880	100,5	1 206 509	194,7	16 163 382
Gauteng	504,0	26 712 000	198,9	3 381 300	251,1	3 012 960	292,7	24 297 159
KwaZulu Natal	42,0	2 226 000	2 605,4	44 291 562	198,5	2 382 086	394,0	32 702 246
Limpopo	70,0	3 710 000	54,7	930 580	133,6	1 602 854	125,1	10 386 459
Mpumalanga	224,0	11 872 000	270,1	4 591 054	210,3	2 523 706	451,8	37 500 512
Northern Cape	308,0	16 324 000	18,1	307 496	33,2	398 477	4,2	349 055
North West Province	140,0	7 420 000	339,7	5 774 220	111,4	1 337 146	606,4	50 331 517
Western Cape	42,0	2 226 000	2 546,1	43 284 397	256,5	3 078 106	626,1	51 967 211
Total	**1 764**	**93 492 000**	**10 239**	**174 058 631**	**1 369**	**16 427 348**	**2 854**	**236 861 369**

Table 50: Livestock abattoir waste quantities and methane production capacity potential (GIZ, 2016c)

Province	Total cattle waste production (Million tonnes/yr.)	Expected methane production (m³/yr.)	Total pig waste production (Million tonnes/yr.)	Expected methane production (m³/yr.)	Total poultry waste production (Million tonnes/yr.)	Expected methane production (m³/yr.)
Eastern Cape	22,721	1 192 396	2,894	165 949	N/A	N/A
Free State	15,148	794 931	3,444	197 452	37,610	2 135 551
Gauteng	106,033	5 564 514	18,261	1 047 055	53,310	3 027 028
KwaZulu Natal	30,295	1 589 861	6,277	359 933	46,515	2 641 165

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Limpopo	9,960	522 694	0,890	51 047	19,332	1 097 713
Mpumalanga	22,721	1 192 396	2,738	157 015	27,534	1 563 410
Northern Cape	7,574	397 465	1,366	78 313	N/A	N/A
North West Province	22,721	1 192 396	1,302	74 629	33,837	1 921 331
Western Cape	22,721	1 192 396	7,846	449 898	71,002	4 031 602
Total	**259,894**	**13 639 049**	**45,018**	**2 581 291**	**289,140**	**16 417 800**

GIZ (2016c) estimated the fruit processing waste potential with a focus on apples, apricots, pears, peaches, grapes, mangoes, guavas, pineapples, strawberries, plums, oranges, lemons/limes, grapefruits. The wastewater produced from these fruits is 3 513 144 m^3/yr with additional 1 034 330 m^3/yr of pomace produced. Table 51 provides the estimated distribution of potential methane production from these food processing waste across RSA.

Table 51: Estimated distribution of potential for methane production from food processing waste on a provincial level (GIZ, 2016c)

Province	Annual methane production pomace (m^3/yr.)	Annual electricity production (MWh/yr.)	Annual thermal energy production (MWh/yr.)
Eastern Cape	8 337 737	29 182	37 520
Gauteng	10 422 171	36 478	46 900
KwaZulu Natal	2 084 434	7 296	9 380
Limpopo	12 506 606	43 773	56 280
Mpumalanga	4 168 869	14 591	18 760
North West Province	2 084 434	7 296	9 380
Western Cape	14 591 040	51 069	65 660
Total	**54 195 291**	**189 685**	**243 880**

The sugar industry waste quantities and methane production capacity potential can be found in KwaZulu-Natal and Mpumalanga. The wastewater produced from this industry is 3 192 236 m^3/yr with an estimated annual methane production = 5 426 801 m^3/yr. In addition, press mud of 798,059 million tonnes/yr is produced which has an estimated annual methane production = 47 883 538 m^3/yr (GIZ, 2016c).

In RSA, breweries and wineries hold potential for biogas production through usage of the wastewater, spent grain and grape pomace produced. Table 52 and Table 53 highlights the estimated waste quantities and methane production potential for breweries and wineries.

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Table 52: Breweries waste quantities and methane production capacity potential (GIZ, 2016c)

Province	Clear Beer Breweries Wastewater production (m³/yr.)	Expected methane production (m³/yr.)	Clear Beer Breweries Spent grains produced (Million tonnes/yr.)	Expected methane production (m³/yr.)	Opaque Beer Breweries Wastewater production (m³/yr.)	Expected methane production (m³/yr.)	Opaque Beer Breweries Spent grains produced (Million tonnes/yr.)	Expected methane production (m³/yr.)
Eastern Cape	960 000	2 016 000	46,1	3 225 600	337 000,0	707 700	16,2	1 132 320
Gauteng	8 280 000	17 388 000	397,4	27 820 800	337 000,0	707 700	16,2	1 132 320
KwaZulu Natal	2 880 000	6 048 000	138,2	9 676 800	337 000,0	707 700	16,2	1 132 320
Limpopo	600 000	1 260 000	28,8	2 016 000	---	---	---	---
North West Province	---	---	---	---	337 000,0	707 700	16,2	1 132 320
Western Cape	1 800 000	3 780 000	86,4	6 048 000	---	---	---	---
Total	**14 520 000**	**30 492 000**	**697,0**	**48 787 200**	**1 348 000**	**2 830 800**	**64,7**	**4 529 280**

Table 53: Wineries waste quantities and methane production capacity potential (GIZ, 2016c)

Province	Wineries Wastewater production (m³/yr)	Expected methane production (m³/yr)	Grape pomace produced (Million tonnes/yr)	Expected methane production (m³/yr)
Northern Cape	494 741	494 741	20,6	3 628 099
Western Cape	5 258 059	5 258 059	219,1	38 559 101
Total	**5 752 800**	**5 752 800**	**239,7**	**42 187 200**

RSA has 131 WWTW that was identified within the GIZ (2016b) study. The number of WWTW that were assessed to have biogas potential were 87 with only 39 identified with the potential of a feasible CHP project. Of the 39 WWTW, 22 are situated in Gauteng, 5 in the Western Cape, 5 in KwaZulu-Natal, 2 in North West Province, 2 in Eastern Cape, 2 in the Free State and 1 in Limpopo. A summary of the potential for electrical and thermal power produced from biogas for RSA can be found in Table 54.

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Table 54: Summary of the potential for WWTW (GIZ, 2016b)

	Total plant capacity Ml/d	Electrical power kWe	Thermal power kWt
Total "sewage" CHP potential (>10 Ml/d)	5 499	61 370	67 507
Total existing infrastructure CHP potential	4 453	33 369	36 706
Total feasible CHP potential	3 523	27 145	29 860

6.8.2 Human resources

Currently, no specific framework or training facility that focuses on the development of human resource required for the value chain of a biogas project exists. However, the GIZ (2016a) study highlighted and modelled the skills required and development of those skills within the existing framework for skills development within RSA. The framework of policies that dictate and guide skills development with RSA can be seen in Table 55.

Table 55: South African Frameworks and Policies associated with Skills Development (GIZ, 2016a)

Framework/ Policy	Function
National Qualifications Framework (NQF)	- Sets boundaries, principles, and guidelines to provide a base and structure for the qualifications system - The system allows for national recognition of learner achievements, and ease of understanding of learner qualifications and knowledge
Organising Framework for Occupations (OFO)	- Links occupations to specific skills and identifies training needs - Provides a skills-based classification system in the RSA context in terms of skill level and specialisation as attributes of a job - Allows a parallel to be found within the NQF
South African Qualifications Authority (SAQA)	- Oversees the development and implementation of the NQF, in terms of regulations specified in the National Qualifications Framework Act (No. 67 of 2008)
Quality Council for Trades and Occupations (QCTO)	- Develops occupational qualifications according to the OFO in order to meet industry needs - Figure 38 contains an excerpt from the QCTO application process that details the information required when applying for registration of a qualification
Energy and Water Services Sector Education and Training Authority (EWSETA)	- Responsible for coordinating, facilitating and providing quality assurance for sector reliant skills development programmes for stakeholders and managing skills through the National Skills Development Strategy (III), all associated with the water and energy sectors - Implements skills plans by establishing learning programmes, approving Working Skills Plans and Annual Training Reports - Allocation of grants to employers, education and training providers and workers as well as education monitoring and training in the sector falls under EWSETA - Facilitates learnerships with employers in terms of workplaces and supporting creators of material

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Using these defined framework and policies, the skill level, NQF and OFO major groupings can be compared to the Paterson grading within the Paterson table (Table 56).

Table 56: Expected skill level required for various Organising Framework for Occupations (OFO) groupings (GIZ, 2016a)

NQF	Skill level		Paterson Table	OFO Major Groupings
7-10	**Higher Education & Training** 1st degrees, second and tertiary education leading to higher qualifications	Highly skilled	E/F	Top/Senior Managers
			E/F	Professionals
6	**Higher Education & Training/ Further Education & Training** First stages of tertiary education	Skilled	C/D/E	Managers
			C/D/E	Technicians & Associate Professionals
3-5	**Further Education & Training** Secondary level of education	Semi-skilled	B	Clerical & Support Workers
			B	Services & Sales Workers
			B	Skilled agriculture, forestry, fisheries, craft & related trades
			B	Plant & machine operations & assemblers
1-2	**General/Basic Education & Training** Primary level of education	Un-skilled	A	Elementary workers

There are several institutes and programmes (Table 57) that can assist in skills development for biogas projects. These institutes also hold potential for the development and delivery of specific accredited skills development programmes that would be internationally recognised. The South African Renewable Energy Centre specifically has been successful in developing formal training programmes for solar PV and wind technologies and have the skills required to develop a formal training programme for biogas technologies.

Table 57: Institutes and programmes in South Africa in the renewable energy and biogas industries (GIZ, 2016a)

Framework/ Policy	University affiliation	Programmes offered	Link
South African Renewable Energy Technology Centre (SARETEC)	Cape Peninsula University of Technology	Short courses and formal training courses	http://www.saretec.co.za/
Sustainability Institute	University of Stellenbosch	Postgraduate programmes, short courses	http://www.sustainabilityinstitute.net/

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Centre for Renewable Energy and Sustainability Studies (CRSES)	University of Stellenbosch	Postgraduate programmes, short courses, workshops, lectures	https://www.crses.sun.ac.za/
Centre for Energy Research	Nelson Mandela Metropolitan University	Postgraduate programmes, short courses	http://energy.nmmu.ac.za/
Environmental and Process Systems Engineering	University of Cape Town	Postgraduate programmes	http://epse.uct.ac.za/
Energy Research Centre	University of Cape Town	Postgraduate programmes	http://www.erc.uct.ac.za/
Risk and Vulnerability Science Centre	University of Fort Hare	Postgraduate programmes	http://ufh.ac.za/centres/rvsc/introduction
Dicla Training Centre		Sustainable agriculture practices	http://www.diclatraining.com/training_courses/index.asp
InternationalEs Biogas und Bioenergie Kompetenzzentrum (IBBK)		Biogas Training Seminar and Study Tour	https://ibbk-biogas.com/training-courses/
National Cleaner Production Centre (NCPC)		2-day end user & 9-12-month expert biogas systems optimization courses offered	http://ncpc.co.za/biogas

The GIZ (2016a) study highlighted the full-time equivalent jobs from a jobs plot model for both existing biogas sites as well as potential job forecast up to 2030 (Table 58).

Table 58: Predicted FTE jobs from jobs plot study (GIZ, 2016a)

Jobs currently in operation phase of biogas industry	270 FTE
Conservative job forecast to 2030	59 000 FTE
Optimistic job forecast to 2030	88 000 FTE

Although biogas projects have a high potential for creating high skill jobs, as shown in Table 58, the lack of a biogas training framework means that South African biogas projects are required to upskill and training own operators. An established biogas training framework would reduce the risk for biogas projects in terms of commissioning time for improved operation and maintenance. However, the viability of establishing a biogas training framework would be dependent on the number of implemented projects within RSA.

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6.8.3 Infrastructure and support industry

An infrastructure and support evaluation for RSA was completed within the Bio-Energy Atlas (Hugo, 2016) to demonstrate if 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 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 45).

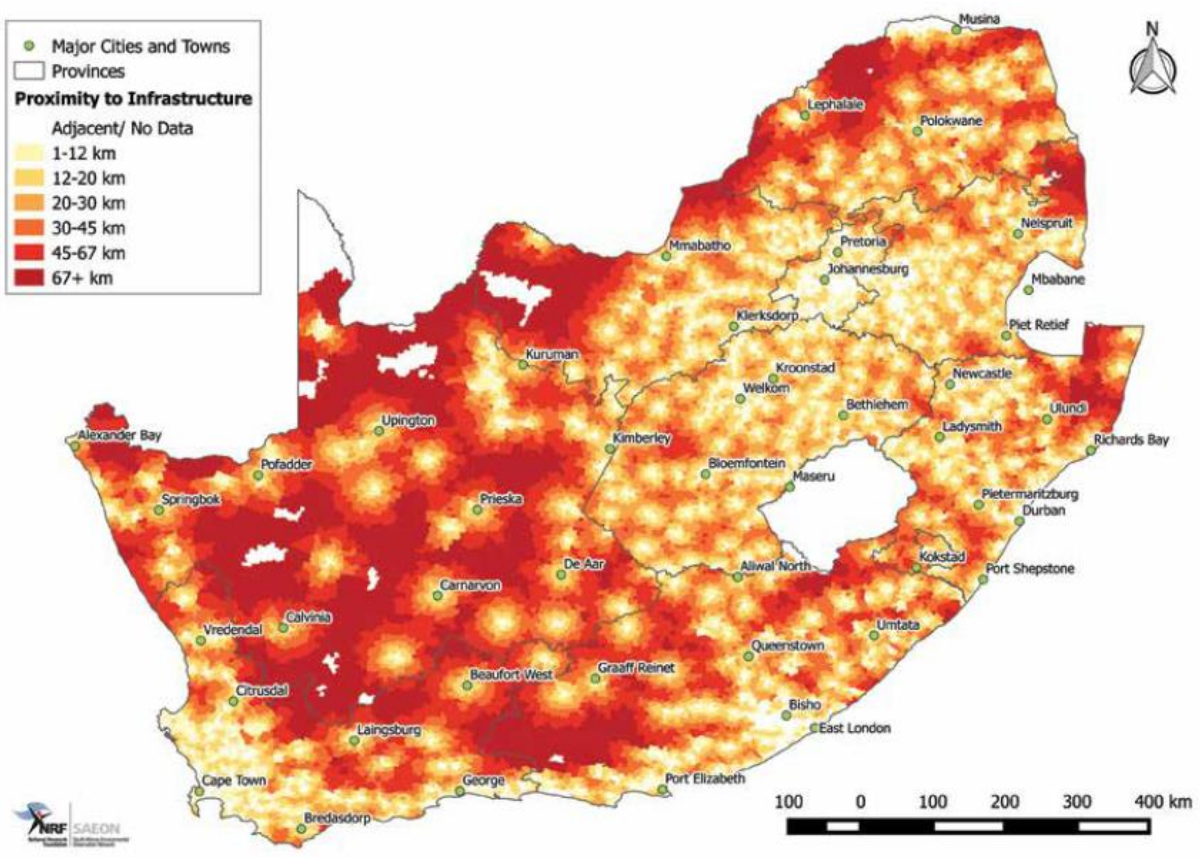

Figure 45: Proximity of the closest infrastructure (of all types) to each location in RSA (Hugo, 2016)

Figure 45 shows that RSA 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.

The RE portfolio has been previously covered in Section 6.4.2 as part of the IRP and REIPPP. The current base load electricity infrastructure can be seen in Table 59.

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Table 59: Eskom's entire generation fleet

Type of Station	Source	Installed Capacity (MW)	Installed Capacity (%)	Capacity Generated (GWh)	Capacity Generated (%)
Base loads	Coal-fired stations	36 479	83%	200 210	91,45%
	Nuclear power	1 860	4%	11 580	5,29%
Mid merit/peaking stations	Pumped storage stations	2 724	6%	4 590	2,10%
	Hydro stations	600	1%	1 029	0,47%
	Open cycle gas turbines (OCGTs)	2 409	5%	329	0,15%
Self-dispatching	Sere Wind Farm	100	0%	1 202	0,55%

Typically, the base load plants generate all day electricity, mid-merit plants generate electricity before the morning and evening peak demand with a 10% to 40% capacity factor supplement the gaps during high peak demand; and the Sere Wind Farm is Eskom's own renewable energy plant. Base loads power stations operate continuously 24 hours a day to ensure there is always electricity available for different end users with different energy demand profiles.

There is an ongoing plan to decommission the coal fired stations approaching end of life, IRP 2019 has indicated a target to decommission 11 GW by 2030. Over the years, the plants have experienced declining generation capacity. In the recent IRP 2019 draft report, the coal decommissioning process is reported to kick off in 2019, decommissioning 2.7 GW of coal. This submission brings forward the decommissioning of Grootvlei, Komati and Hendrina[110]. Another factor driving coal decommission, is the Air quality regulations under the National Environmental Management Act that regulates coal plants under Eskom's fleet to meet the minimum emission standard (MES) by a certain time, otherwise the non-compliant plants would be illegally operated, if not shut down. Although the RSA is currently in an energy crisis, biogas projects have the potential to reduce the energy load demand particularly if implemented at WWTW and large energy demand agri-processing sites.

Local manufacturing of biogas project equipment and parts are limited in RSA. This is mainly a result of the small number of projects implemented per year. However, RSA does favour local manufacturing and the development of local manufacturing lines as can be seen in designation of a special economic zone in Atlantis, Western Cape. This is an opportunity for EU technology and equipment suppliers to collaborate with local stakeholders in establishing local manufacturing facilities as the local biogas market grows.

RSA has an existing infrastructure and potential for development that can currently support the uptake and implementation of biogas projects.

[110] Department of Energy (2019). Integrated Resource Plan 2019

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