The potential for electricity generation from Biogas in South Africa

A potential study as part of the BAPEPSA project

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Abstract

The Netherlands and South Africa acknowledge the potential of biomass and therefore launched the Biomass Action Plan for Electricity Production (BAPEPSA) in 2014. In this government to government cooperation, South Africa's Department of Public Enterprises (DPE), Department of Energy (DOE) and the Netherlands' Ministry of Economic Affairs are leading the project in collaboration with Eskom, research institutes and NGOs. As part of BAPEPSA, this study focuses on the biogas potential for electricity generation in South Africa. It is a comprehensive overview of available wet waste streams for energy production. In conclusion, the report contains recommendations to overcome barriers to further develop the biogas market. These recommendations will be a part of the Biomass Action Plan (Main Report) expected to be published early 2017.

Contents

Summary

South Africa is required to expand its current electricity supply systems in the coming years. During this expansion process, South Africa intends to diversify its primary energy mix to include a higher level of renewable energy supplies. The county's flourishing renewable energy market has seen the highest year-on-year growth globally with now ca. 2 GW installed wind and PV capacity, ca. 5% of the country's power generation. The role of biomass with less than 100 MW, (ca. 0,2%) however, still lags behind.

Next to solid waste and woody biomass, it is clear that usage of wet waste streams offers opportunities to produce biogas and generate electricity. Unlike foreign markets (e.g. Germany, the Netherlands, UK, India, China) this source of energy production is underrepresented in South Africa's energy mix. It is estimated that at the very most 700 digesters produce ca. 50 to 70 MW of electricity in 2016.

To further stimulate the development of the biogas sector there is a clear need for a comprehensive overview of the available wastes and residues. This report provides an insight into the potential of various available feedstock and estimates biogas production for electricity generation in South Africa. With respect to the feedstock data the recently published BioEnergy Atlas has been the leading source of information. In addition, for those waste streams that were out of scope of the atlas, available statistics and sector data have been used. In order to come up with feasible production figures, the calculation model of the Dutch sector agency Groengas Nederland and the key conversion ratios of ECN have been applied.

The estimated, feasible, economic potential for biogas production equals more than 650M m^3 per year. In terms of electricity this means ca 450 MWe could be generated. This equals to an almost tenfold increase of the current production and about 1,7 % of the countries' electricity supply in terms of net output (based on StatSA, 2014)[1]. On a different note this means 2,5% of the renewable energy target in 2030[2].

[1] http://www.iea.org/ciab/South_Africa_Role_Coal_Energy_Security.pdf

[2] Department of Energy (2015), State of Renewable Energy

At this moment, landfill sites seem to be the most economical way to produce biogas at a large scale. However, stimulating this would contradict the governments vision of zero waste to landfill in 2022. So, considering scale and costs, municipal organic waste and waste water are the low hanging fruit for further biogas development. These two streams account for one-third of the total potential and are economically viable if the granted tariff is in the range of R 1,47 per kWh (€ 0,15). To put this price level into perspective: it is at about twice the IPP tariff (Bid Window 4, expedited) for Solar PV (R 0,62) and Wind (R 0,62). Moreover, the delta with newly built coal fired plants, is much less with an estimated costs between R 1,05 and R 1,16[3].

With hundreds of thousands households living in rural, off-grid areas, small scale rural biogas production for both cooking and electricity purposes is still untapped in South Africa. Although there are some initiatives in this segment, the involvement of International Climate Funds may be an opportunity to ramp up the development.

Most of the barriers to unlocking the potential are in the regulatory space. Firstly, legislation of waste streams is often not designed to facilitate energy production. For example, the term of (municipal) tender bids does not match the operational period of a waste to energy plant.

Secondly, the current Independent Power Purchase (IPP) program focuses only at projects larger than 1 MW. For smaller projects there is a limitation on revenues; projects below 1 MW are not allowed to connect or sell electricity to the national grid. Thirdly, developers face project-threatening red tape. A striking example is the 4.4 MW Bio2Watt biogas plant near Pretoria. It took almost 8 years from project launch until the first biogas has been produced.

Alternative tariff structures that take the base load function of biogas and avoided methane emissions into account are subject to further study. A pricing structure that reflects the benefits of biogas production, e.g. base load power and avoided methane emissions, will help to further improve the business case and prospects for the sector as well as contribute to meeting South Africa's ambition to reduce CO_2.

[3] Based on Levelized Cost of Electricity (LCOE) calculation for Medupi and Kusile power plants, CSIR (2016) http://www.ee.co.za/wp-content/uploads/2016/10/New_Power_Generators_RSA-CSIR-14Oct2016.pdf

1 Introduction

Bioenergy is the single largest renewable energy source today, providing 10% of world primary energy supply. In South Africa the role of bioenergy in the energy mix is primarily wood and sugar cane bagasse. In 2010, the year the latest available South African Energy Synopsis has been published, biomass contributed about 10% of South Africa's primary energy. Now six years later, due to the upscaling of solar PV and Wind the share of biomass is expected to be less than the global average.

The diversification of its energy supply is critical to meet various developmental and sustainability goals. Furthermore, the increase of electricity demand, the intermittent character of renewable energy sources like solar and wind and the need to further decarbonize South Africa's energy production play a role in the configuration of the future energy mix. This has been recognized by the South African and Dutch government resulting in a Government (G2G) co-operation formulating a Biomass Action Plan for Electricity Production in South Africa: BAPEPSA.

Raw biomass materials can be broadly classified into wet or dry resources as well as liquids or solids. Biomass with a high moisture content is usually preferred for anaerobic digestion (AD), pyrolysis or for biofuel production whereas dry solid biomass is preferred for combustion or gasification. Bioenergy carriers can range from a simple firewood log for domestic heating to a highly refined liquid transport fuel for blending in large volumes. Different biomass products therefore suit different situations.

The original scope of BAPEPSA has been limited to dry resources, like woody and agricultural biomass. In addition, this study focuses on wet resources. Gradually it became clear that the role of biogas in electricity generation especially as base load power and as small scale solution (for instance in rural areas) plays a vital role in security of supply. Therefore, the Dutch Enterprise Agency (RVO) has requested the Energy research Centre of the Netherlands (ECN) to draw up a high level road map for biogas in South Africa.

ECN has a track record in policy development in biogas. So, for example, The Green Gas Roadmap (2014) study commissioned by the Ministry of Economic Affairs outlines the potential for biogas in the Netherlands until 2030. In South Africa, ECN had been involved in a study on bio-energy in South Africa (2013).

In line with the BAPEPSA project this addendum will not evaluate and assess the biomass availability and costs of technologies in detail, but rather build on existing reviews and available data. A list of consulted literature can be found at page 32.

Approach

In South Africa, coherent feedstock and biogas data providing a comprehensive picture of the total potential are missing. Therefore, this study uses various actual sources to obtain these data of the different waste streams. The recently published BioEnergy Atlas data are used as core data. However, since the level of granularity for some waste streams is lacking, additional data sources have been used. In addition, recent studies serve as reality check for the application of feedstock data.

In order to estimate the potential biogas production and electricity generation the ECN and Dutch sector ratio are applied. Data as feedstock to biogas and electricity ratios are taken from the Dutch Roadmap Green Gas prepared by amongst others ECN and Groengas Nederland in 2014. Since 2008 ECN and DNV KEMA advice the tariffs of the Dutch subsidy scheme SDE, including biogas and CHP. These figures are also based on historical, operational data collected from biogas production sites. The detailed values for organic dry mater and CH_4 content can be found in appendix, table 15 and table 16.

What is biogas?

Biogas is a **secondary** energy carrier that can be produced from many different kinds of organic materials via either a chemical process (digestion) or a thermal process (gasification). The latter is still in the R&D phase, but can potentially accelerate the development of biogas as it has the potential for larger produced volumes. Biogas is considered as carbon neutral as the carbon in biogas comes from organic matter (feedstock for biogas production) that captures this carbon from atmospheric CO_2 over a relatively short timescale.

The composition of biogas, the unrefined gas mixture obtained from digestion, contains approximately (40–70%) methane (CH_4), CO_2 (30-60%), H_2O (0-1%), and traces of other components such as H_2S (0-3%)[4]

AD Technologies

Anaerobic digestion (AD) is the biological degradation of biomass in oxygen-free conditions. In the absence of oxygen, anaerobic bacteria will ferment biodegradable matter into biogas. The two main technologies available are Mesophilic and Thermophilic Digestion. The main difference between these technologies is that for Thermophilic a higher heat energy is demanded. This technology has a larger gas output capacity and a higher methane gas content. Nevertheless, Mesophilic anaerobic digestion is the most common system due to a more stable operation and lower operational costs.

[4] Welink, J-H., Dumont, M. and Kwant, K., 2007. Groen gas: gas van aardgaskwaliteit uit biomassa: update van de studie uit 2004, SenterNovem, pp. 34.

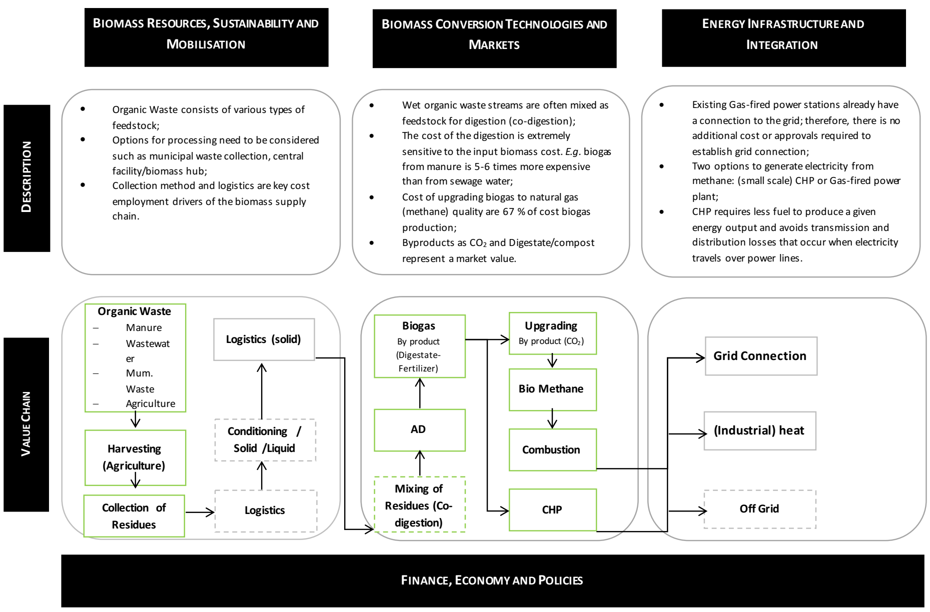
Applications

Biogas obtained via anaerobic digestion, primarily methane (CH_4) and CO_2, can become useful via various routes:

- Direct combustion for heat production.
- Combustion in a CHP (cogeneration) plant to produce electricity and heat.
- Upgrading (such as through the removal of CO_2) to natural gas quality, then:
  - Injecting into the gas grid, to be used as regular natural gas, also known as green gas
  - Compression, then use in transport (CBG, internal combustion engine running on green gas).
  - Liquefaction (turning into a liquid) by cooling into LBG, then use in heavy transport (road, shipping).

The scope of the BAPEPSA project is limited to electricity generation, heat and small scale off-grid solutions. Therefore, the focus of this report is predominately at electricity production by means of the cogeneration technology (CHP). The potential of (small scale, rural) direct combustion is addressed to a limited extend. The considered value chain is described in Figure 1.

Figure 1: Value Chain wet waste streams, anaerobic digestion and biogas



2

Biogas in the Netherlands

The Netherlands is a country with a strong gas history since it discovered wells in the late 1950s. Based on the country's own gas supplies (2.800 billion m^3), gas makes up nearly 50% of the primary energy source for all energy applications. Consequently, the Netherlands still uses natural gas more intensively than any other country in the world. 98% of all households are connected to the gas grid (Energy Delta Gas Research, 2012)

Since 1987, the Netherlands has been experiencing in the upgrading of biogas from landfill sites to a natural gas quality and injecting this into the natural gas grid. Thanks to the developments in waste management landfilling has decreased substantially in the country (only 1.5% of the total municipal waste).

The last years the consumption of natural gas in electricity generation decreased due to increasing consumption of renewable energy, import of cheap renewable electricity from Germany, the low coal prices and the commissioning of new coal plants resulting in record consumption of coal (ECN, PBL, CBS, RVO, 2016)

The role of CHPs in the total power generation has always been significant in terms of installed capacity. The growth of CHPs came to an end in 2013, but the share is still 35% in electricity production (Groengas Nederland et al, 2014). In 2012, 94% of the produced biogas was still used as fuel for CHPs (Groengas Nederland et al, 2014). However, as a result of low prices of electricity delivered via the grid, biogas for CHPs is losing its popularity. Hence, the produced biogas is finding its way to new markets, like grid injection. This application of reprocessed biogas is called green gas.

With the introduction of the SDE subsidy scheme in 2008, the production of green gas has been boosted. Starting in the range of 10 million M^3 in 2010, the volume of Green gas injected to the national gas grid now reaches almost 100 million M^3. Supported by European renewable fuel regulations, the transport sector is now one of the main markets for (compressed) green gas.

As a result of upscaling in the recent years, prices for green gas production came down. In comparison with 2010 cost prices dropped with ca 15% across all types of feedstock, excluding mono-manure[5]. In a recently launched program “Jumpstart” the dairy sector and the Ministry of Economic Affairs have joined forces to boost the innovation and installation of manure mono-fermentation systems. Besides the generation of renewable energy, the program with a budget of 150 M euro targets a reduction of emission of greenhouse gases, including methane[6].

Table 1: Key Statistics Biogas in the Netherlands

			Year
No. Biogas Installations		150	2015
Volume Biogas	(in M m3)	128	2015
Volume Green gas	(in M m3)	80	2015
Electricity	(in M kWh)	1.148	2015
Cost prices	(euro/kWh)		
	Waste Water	0,032	2016
	Manure (Co -Digestion)	0,062	2016
	Manure (Mono)	0,106	2016
	Other	0,06	2016
No. Natural Gas Vehicles		11.070	2016
No. CNG and LNG pumps		165	2016

Source: ECN (2016), CBS (2015), RDW (2016)

5 ECN basisbedragen 2010-2016

6 https://groengas.nl/jumpstart-monomestvergisting/

3

Biogas in South Africa

General

In 1957, the world's first commercial anaerobic digester was built in South Africa. 69 years later, largely due to cheap power and despite expanding landfills, the biogas sector is still in its infancy [7]. South Africa has between 400 and 700 digesters installed, half at Waste Water Treatment Works (WWTW) built in the late 1970's and early 1980's. The majority are aid funded rural digesters. Only a handful of digesters at commercial institutions[8].

As of April 2016, there are about 1.700 people directly employed in the biogas industry, with 38 commercial projects in operation. A (non- exhaustive) list of commercial projects can be found in the appendix, table 13. It is estimated that these projects have an installed capacity of 50 MW – 70MW.

Electricity

With an estimated installed capacity of 50-70 MW[9], electrification is the dominant market for biogas in South Africa. The most common commercial non-residential use of biogas is for the generation of electricity either for own consumption, to be sourced to the municipal/national grid, or in exceptional cases to 'wheel' electricity across the grid to a dedicated off-taker.

The lack of a national gas grid and a transport market which is heavily dominated by liquid fuels leave feedstock suppliers and biogas producers no other option. However, the last 10 years were characterized by periods of a shortage in electricity supply and substantial price increases. Electricity tariffs tripled in the last 8 years. Not surprisingly, managing security of supply and becoming less exposed to further electricity price increases have been a strong driver for project developers for their own use. The relevant prices in this regard mostly concern prices in urbanised areas, as these are the areas where waste is available for conversion into biogas.

7 http://www.esi-africa.com/magazine_articles/biogas-south-africas-great-untapped-potential/

8 SABIA, Biogas in South Africa, 2014

9 Various sources, including SANEDI. DOE, GIZ

There is little publically disclosed information on contracted tariffs for decentralized generated power to the grid. A rate which can be used as a benchmark is the Johannesburg Landfill Gas-to-energy Project participating in the The Renewable Energy Independent Power Producer Procurement Programme (REIPPP). This 18 MW IPP project has been contracted by Eskom at a costs of R 1,08 per kWh in bidding round 3. Compared with an Eskom wholesale tariff of ca R 0,76 per kWh ("business rate") that year the price gap (0,32) was a disadvantage for biogas. [10]

A recently published report by the Ministry of Environmental affairs[11] examines prices between the various applications/markets of biogas. On the basis of inputs from local and international stakeholders, as well as data from biogas studies in South Africa, an indicative cost range has been derived for a CHP unit, and for upgrading and compression in the case of transport fuels. These costs are indicative for sizable projects of around 2 MWe or 18.000 Nm^3 per hour of raw biogas and larger.

Table 2: Biogas to electricity; cost price and margin for biogas production

	ZAR		Euro	
	Low	High	Low	High
Sales price (kWh)	R 0,89	R 1,54	€ 0,06	€ 0,10
Sales price (GJ)	R 98,00	R 171,00	€ 6,53	€ 11,40
Costs price Biogas (GJ)	R 71,00	R 79,00	€ 4,73	€ 5,27
Margin for biogas production (GJ)	R 27,00	R 92,00	€ 1,80	€ 6,13
Margin for biogas production (per M3)	R 5,33	R 18,16	€ 0,36	€ 1,21

Sources: SANEDI (2016), Ecometrix (2016)

Transport

The application of biogas as transport fuel in South Africa is still in its infancy. To fuel vehicles or vessels, biogas must be processed to a higher purity standard. This process is called conditioning or upgrading, and involves the removal of water, carbon dioxide, hydrogen sulphide, and other trace elements. The resulting bio methane, has a higher content of methane than raw biogas, which makes it comparable to conventional natural gas and thus a suitable energy source in applications that require pipeline-quality gas.

In order to use biogas as a fuel for vehicles and vessels it needs to be compressed (CNG) or liquefied (LNG). Since natural gas has a very low energy density at normal atmospheric pressure in comparison to liquid transport fuels, it is compressed to about 200 bar. CNG is commonly used by passenger cars, vans, buses and (LDV and MDV) trucks, particularly in urban areas where distances to refuelling points are relatively short.

An alternative process is liquefaction of the natural gas is condensed into a liquid at close to atmospheric pressure by cooling it to approximately −162 °C. In a liquefied form the volume decreases by a factor of 600. This makes it easier to transport the LNG to

[10] http://www.eskom.co.za/CustomerCare/TariffsAndCharges/Pages/Tariffs.aspx

[11] The facilitation of large-scale uptake of alternative transport fuels in South Africa, The Department of Environmental Affairs, 2016.

the tank and bunker stations and the amount of gas in a (LDV) truck or vessel fuel tank is higher, which increases the range of the vehicle or vessel.

At the moment only 3 CNG fuel stations are operational, all located in Gauteng (Johannesburg and Pretoria). Off-takers are predominately minibuses taxis and (retrofitted) city busses.

Pricing of biogas in transport market

Compared to the alternative application of biogas such as heat and power generation (CHP) transport is generally to be considered as a more attractive market. The price for biogas in this market is compared with transport fuel prices rather than electricity prices.

Let's assess the case for South Africa in more depth. Fuel prices are relatively low, 10 % below world average. In October the average price for diesel is € 0,67 per litre. In order to compare with gaseous fuels, we express the price in euro's per GJ. In view of this, fossil CNG with the same characteristics as (upgraded) biogas is the benchmark.

Table 3: Fuel price comparison transport

	Natural Gas		Diesel		Electricity	
	ZAR	Euro	ZAR	Euro	ZAR	Euro
price/ton	2.500	161	7.000	452		
GJ/ton	50		44			
R/GJ	50	3	159	10		
Basic Fuel Price	189	0	510	0		
cent/liter (diesel equivalent)						
Retail Price cent/liter (avg 2016)	799	1	1.037	1		
Retail Price per GJ	304	20	323	22	171	11

Source: Ecometrix (2016), ECN (2016), SANEDI (2016)

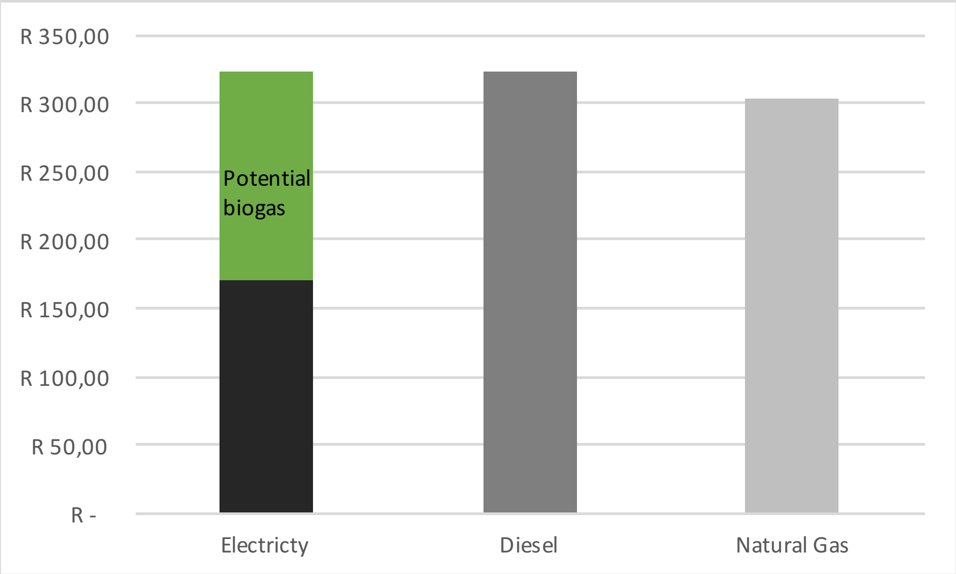
Currently the South African government supports the uptake of CNG as transport fuel by an exemption on fuel levies and taxes that are put on regular transport fuels. As we take a closer look at the difference in fuel prices there is an upward price potential for natural gas (CNG) of about € 0,15 / R 2,5. This falls within the regulated maximum price of R 117,69[12]. Diesel prices are largely governed by international markets. The weakening rand, and upward price pressure will in all likelihood result in future price increases. In addition, the government has tabled a carbon tax bill. The indicated net effect on the diesel price will be another R 0,13 per litre.

In comparison the market price for CBG in transport measured in gigajoules is about twice as high as in the electricity market. All other things being equal, there is an upward potential for a biogas producer to sell in the transport market. However, one must realize that at this moment there is hardly a market since the number of CNG filling stations is limited and pipeline infrastructure is only present in some parts of

[12] NERSA, 2013, Approval of Maximum Prices Application for Sasol Gas

Gauteng. Nevertheless, to further ramp up biogas production, projects where municipal waste (waste water, garden waste) is converted to biogas and used as transport fuel for public transport services are promising.

Figure 2: Sales per GJ in ZAR



Project development

The potential of biogas has generally been acknowledged. According to South African Biogas Industry Association (SABIA) electricity produced from biogas has the potential of supplying ca. 25% of the government target of 10GW generated by renewable energy. The Integrated Energy Plan, published last November, estimates that domestic and industrial refuse have an energy content of 11.000 GWh (1.300MW) a year. This figure has not been underpinned in the document and will be further assessed in Chapter 4.

Since 2010 the REIPPP has been a catalyst for growth. At an industrial scale (> 100 kW) the number of biogas projects is growing. Not surprisingly, most of the projects are located in the Western Cape (Cape Town) and Gauteng (Johannesburg, Pretoria) with various types of municipal and agricultural feedstock nearby. However, in the REIPPP tender process (window 3), until now only the Johannesburg landfill project (18 MW) become operational[13].

Local feedstock inputs comprise municipal and industrial sewerage, waste and process water, manure, plant (sugar cane) waste and indigenous grasses and municipal solid waste. Although an exact breakdown of feedstock currently being used to produce biogas is missing: waste and process water, municipal waste (landfill) and manure are the dominant sources.

A recently published study done by Altgen and GIZ came up with an estimate of project developments for the next 15 years. Numbers have been compiled on the basis of

[13] http://energy.org.za/knowledge-tools/project-database.

stakeholder interviews. The vast majority are small to medium scale projects, smaller than 1 MW installed. It is precisely this segment that doesn't qualify for a IPP status with Eskom as a guaranteed off-taker.

In comparison with other Sub Saharan countries the installed base of small scale rural digesters is limited. It is estimated by SABIA that there are only 400 digesters operational in this segment. Dedicated programs launched by the Department of Science and Technology (DST), the Department of Trade and Investment (DTI) and SANEDI contributed to the rollout of rural bio digesters in the Eastern Cape and KwaZulu Natal. With hundreds of thousands households living in rural areas, small scale rural biogas production for both cooking and electricity purposes is still untapped in South Africa.

Table 4: Project pipeline 2015-2030

	2015	2020	2025	2030
Rural (<10kW)	200	1.250	2.300	3.350
Small scale (<30kW)	100	170	240	310
Medium scale (>30kW <1MW)	10	1.052	2.094	3.136
Large scale (>1MW)	10	43	76	109
Total	320	2.515	4.710	6.905

Source: GIZ (2016)

Policy frameworks

Biogas is addressed in various national policies. As in the Netherlands biogas is within the domain of many ministries as well as local authorities. The Ministries of Energy (DoE), Environment, Agriculture, Science, Economy, Water, and Public Enterprises are involved in policy issues related to waste and biogas.

The most relevant policies are the Energy Policy White Paper (1998), White Paper on Integrated Pollution and Waste Management (2000) Renewable Energy Policy White Paper (2003), Free Basic Alternative Energy Policy (2007), Integrated Resources Plan (IRP 2010), National Climate Change Policy White Paper (2011) and the recently published draft IRP (2016)

Awaiting an update of the IRP, DoE in collaboration with GIZ planned to come up with a national biogas strategy in the first half of 2016. The latest update however is that parties are working on a bio energy strategy to be published in 2017.

Within the context of this study we only considered those policies that have been identified either as barrier or stimulus for the biogas sector. With reference to the BAPEPSA project this analysis is coherent with *Activity II Task 3:* "Identification of Solutions for the Barriers for Woody and Agricultural Biomass Implementation in South Africa".

Published by the DoE in May 2011, the Integrated Resource Plan 2010-2030 is the key document that provides a long-term plan for electricity generation. The IRP 2010 sets a target of 17.800 MW from renewable energy sources by 2030. In order to implement this ambition, the government launched a Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) accordingly. The IPP is done through a competitive tendering system with feed-in tariffs (REFIT) used as caps. This competitive bidding process, as it has become apparent in South Africa, has a great potential to lower prices while still providing adequate incentives for market entry by investors.

In the 4 completed bidding rounds, in total the IPP has delivered more than 6.500 MW of submitted projects. The IPP Office of the Department of Energy has undertaken a further "expedited" round for Bid Window 4, which is still under review and involving an additional capacity allocation of 1,800MW. Wind (53%) and Solar (PV: 35%, CSP: 11%) dominate the charts with already 2.500 MW operational. The role of biogas in the IPP program has been limited to 96 MW of which 18 MW (landfill Johannesburg) is operational.

The reason is projects below 1 MW are not being able to connect or sell electricity to the national grid. On top of that, prices for biogas have been caped to R 1,475 (€ 0,15) per kWh which is according to project developers not feasible in most cases. The initial sunk costs of presenting a bid under the REIPPP are too high. How to overcome this barrier will be addressed in recommendation chapter 5.

A perceived barrier of a different nature has to do with regulations on waste and environment. In the absence of a dedicated legislative framework for biogas, a plethora of Acts and Regulations need to be consulted prior to the approval for the development of a biogas plant.

These include:
- National Environmental Management Act (NEMA)
- National Environmental Waste Act (NEM;WA)
- National Environmental Air Quality Act (NEM:AQA)
- National Environmental Biodiversity Act (NEM:BA)
- National Environmental Protected Areas Act (NEM:PAA)
- National Heritage Act
- National Gas Act
- National Water Act
- Spatial Planning and Land Use Management Act
- Municipal planning regulations.

SABIA has established a working group that has ongoing consultations with the Department of Environmental Affairs to standardize regulations for AD. Especially, there is a need for classification of abattoir waste. The Department of Agriculture confirmed all abattoir waste materials to be 'general' waste on condition that sick and potentially sick animals are isolated and slaughtered separately, or that an abattoir confirms it slaughters only animals with verified (clean) ante-mortem certificates. Infectious condemned abattoir waste is excluded from the Biogas Standards[14]. In addition, it has been advised that all organic feedstock will classified under the existing standards for AD. Moreover, the digestate is not always acknowledged as being safe and can still be considered waste, therefore limiting the opportunities to use the nutrients and sell it.

[14] SABIA, 7 July 2016. Environmental & Technical Standards Working Group Feedback

Socio economic development

Next to renewable energy production, one of the REIPPP objectives is to enhance socio economic development. Awarded projects are required to spend a certain amount of their generated revenue on Socio-Economic Development (SED), Enterprise Development (ED) and share ownership in the project company with local communities. These criteria, as well as the creation of a specific number of jobs, are intensified through awarding higher scoring to projects that realise such criteria within a 50 km radius to the project site during the evaluation process.

A recent study of Altgen commissioned by GIZ shows that biogas projects create a significant number of local jobs, on average 57 FTE per MW [15]. The method used is the employment factor: FTE jobs (person-years or persons) per unit of energy output (MW) and are specific to both technology type and project phase. Outcomes differ considerably per project stage and size of the project.

Based upon the current pipeline of known projects (see table 4), the number of jobs in the biogas sector could grow from 192.554 in 2020 to 361.227 ten years after. Bearing the current number of less than 2.000 FTE jobs in mind, this would mean a spectacular growth rate. The vast majority of employment (80%) has to come from rural projects that are less than 10 kW each.

Nevertheless, there is a caveat. Project developers estimate about only 3.000 rural projects in 2030. This is due to the other requirements for rural scale projects like low profit margins and high cost risks. It is questionable whether commercial developers will step into this market unless governmental aid is involved.

[15] Altgen, GIZ, An assessment of the skills need and estimation of the job potential

4

Feedstock and biogas potential

General

In South Africa the majority of waste ends up in landfills as mixed waste. According to the latest available statistics of the South African Ministry of Environment the country generated approximately 108 million tonnes of waste in 2011. Of this total 59 million tonnes were general waste and the remainder hazardous and unclassified waste[16]. Only 10% of the general waste was recycled and the remaining 53.5 million tonnes is landfilled. In the National Waste Management Strategy, the government targeted to divert 25% of recyclables from landfill for reuse, recycling or recovery by 2015.

A significant barrier to recycling and recovery is that tipping fees at the majority of South Africa's landfill sites remain very low R150 per ton/ € 10/ton. In comparison, in Northwest Europe gate fees are in the range of € 100-150/ton[17]. In South Africa, the low fee makes alternatives such as recycling and recovery more expensive compared to disposal.

A bottom up calculation of the potential of biogas by using the total waste number is not realistic. The Economic and Financial Calculations and Modelling for the Renewable Energy Strategy Formulation document (DME, 2004) identified 57 feasible landfill to energy sites ranging from micro (646 kW) up to large (4MW) in South Africa. These sites estimated to produce 43 million m^3 of methane gas. More than 10 years later, this number is still quoted as potential for landfill gas.

Hence, the strategy of the government is to reduce the share of non- organic solid waste by reuse, recycling and recovery. The scope of this study is limited to the organic fraction of municipal solid waste[18].

16 Department of Environmental Affairs (2012), National Waste Information Baseline Report

17 European Environment Agency (2013), Typical charge (gate fee and landfill tax) for legal landfilling of non-hazardous municipal waste in EU Member States and regions

18 http://www.wasteroadmap.co.za/download/waste_rdi_roadmap_summary.pdf.

As described in the introduction, organic waste data cohesion is an issue. Nevertheless, thanks to the recently published BioEnergy Atlas data and various feedstock data of industry bodies and research agencies such as SABIA, CSIR, GreenCape, GIZ etc. it is possible to assess the potential for biogas production from organic waste in South Africa.

Feedstock, organic waste in South Africa

According to an internal project document prepared by DNV GL, for South Africa, the most accessible waste streams for anaerobic digestion seem to be the waste streams of food and beverage (fruits, beer) industry, the organic fraction of the municipal waste and manure [19]. Based upon the volumes of sewage sludge this waste stream must also be included.

Accurate estimates and underpinning data of available feedstock for biogas production is generally acknowledged as barrier for both policy makers, developers and investors to take the sector to the next level. The latest nation-wide industry census was performed in 2011. However, a disconnect was noted between private industry associations statistics and public sector data (GIZ, Biogas Industry in SA).

To meet the sectors ambition and to overcome the lack and inconsistency of data a project funded by the South African Department of Science and Technology has been launched in 2012. In the BioEnergy Atlas project SAEON/ NRF with the assistance of a number of collaborators in academia, research institutions, and government work together to build an online data tool that provides insights in biomass availability at various geographical scales.

The feedstock numbers of animal and agricultural waste as mentioned below are mostly limited to industrial scale farms. Henceforth, rural stock of cattle, pigs and chickens are out of scope due to the lack of available data.

Agricultural Waste

Estimating the residues of agricultural production has proved to be a difficult exercise. The main reason is the definition issue. There appeared to be an overlap between food processing residues, industrial organic waste and specified crops as maize, wheat and sugar cane etc.

Therefore, the starting point of the data analysis has been the “Agricultural Residues” category in the Bioenergy atlas. The theoretical potential is highlighted as almost 4.5 billion m^3 biogas a year in this study. However, there are barriers to unlock these agricultural waste streams, such as transport costs (if the electricity production/usage is at some distance from the source of the waste). Besides, many crops, fruit and vegetable waste streams have a commercial value as they are used for compost, mulch and animal feed.

Nevertheless, in this study we have tried to come up with a ballpark figure. Second to sugar cane (which is a separate category in this report) with 30% share in total crop production maize is the dominant crop that grows in South Africa. FAO data shows that

[19] DNVGL, Rapport BAPEPSA deliverables, 5 February 2016 – (Internal project document)

maize production will be 7,7 million tons in 2016. [20] The potential of harvest residue also known as maize stover available is estimated in a recent study compiled by the University of Utrecht. [21] According to their desktop exercise the residue to production ratio (RPR) for maize in South Africa is 1.

It is also assumed that 90% is used as fodder and nutrient, leaving only 10% for energy production. Applying the conversion ratio for maize (appendix, table 15) maize residues could count for almost 135 million M^3 of biogas. This number is in the same range of the estimate EcoMetrix has determined in their study.[22] In conclusion, also including waste from other crops production into account, a biogas production of 150 million M^3 seems to be realistic.

Table 5: Agricultural Waste

	Biogas (in m^3)	MWe	PJ
Theoretical potential	4.408.634.843	1179	87
Feasible potential	150.010.985	103	3
Feasible potential (maize residues only)	134.569.050	93	2,7

Source: BioEnergy Atlas (2016), EcoMetrix (2016), FAO (2016), ECN (2016)

Manure

The BioEnergy Atlas does not include cattle, piggery, and chicken manure due to lack of data. Notwithstanding, this study provides an estimate of energy production from this kind of biomass.

The biogas content for liquid and solid manure differs. The ratios are approximately 22 m^3 and 90 m^3 per ton manure, respectively, according to the data analysis of operational digesters. In practice both fractions are mixed in a 50:50 ratio, resulting in a biogas yield of 27 to 35 m^3 per ton. These ratios are used by the Dutch Biogas and Greengas Association (www.ggnl.nl) and also used for the determination of the Dutch subsidy scheme SDE+.

There are an estimated 1 834 dairy farms operating in South Africa. The number of cows per milk producer varies from 76 (Northern Cape) to 769 (Eastern Cape), averaging at 353 cows per producer (Milk SA & Milk Producers' Organisation, 2015)

Since the size and professionalism of farms in South Africa vary heavily and manure is not collected in most cases, the potential of manure digestion needs to be assessed. A recent study by ARC (2016), has limited the number of dairy farms feasible for biogas production and taken only the ones with at least 400 cows into account[23]. Based upon

20 http://www.fao.org/giews/countrybrief/country.jsp?code=ZAF

21 M. Valk, Availability and costs of agricultural residues for bioenergy generation

22 EcoMetrix,, Facilitation of the Large-Scale Uptake of Biogas for Transport, Department of Environmental Affairs

23 http://www.biogasassociation.co.za/website/downloads/Meetings/NBP15_Agrowaste%20Resource%20Assessment_MaryJane%20ThaelaChimuka.pdf

mono-manure digestion there is a potential for almost 400 M m^3 of biogas production. However, in practice it is likely that manure will be mixed with other feedstocks since digestion of crops with manure results in a higher biogas yield and increases the economic viability.

On top of commercial farming there is an untapped potential for small scale, rural farming. A study done by project developer AGAMA in 2008 (based on the latest agricultural census in 2007) identified 300.000 households that could make use of the technology to meet all their cooking energy requirements. With a few exceptions, considering the scale of each installation, it is not expected that the produced biogas will contribute to electricity generation.

Table 6: Cattle Manure

	Biogas (in $m^{3)}$	MWe	PJ
Solid	222.795.048		
Liquid	158.760.000		
Total	381.555.048	262	7,5

Source: ARC (2016), ECN (2016), GGNL (2014)

Pig Manure

As with dairy and beef cattle farms there is a minimum size of piggeries that are taken into the equation. The minimum level is considered as 750 pigs per farm, resulting in 855.591 pigs in total. The conversion ratio used by the sector in the Netherlands (appendix, table 15) differ from those applied by ARC. Therefore, the theoretical yield of biogas production and electricity generation is lower than presented by ARC. In Holland, the threshold value for a feasible business case is a pig farm with a minimum of 2.000 pigs. To deduct a feasible number for biogas production this study assumes that 20% of the piggeries qualifies for a biogas digester.

Table 7: Pig manure

	Biogas (in m^3)	MWe	PJ
Theoretical potential	25.051.704	17,2	0,5
Feasible potential	5.010.341	3,4	0,1

Source: ARC (2016), ECN (2016), GGNL (2014)

Chicken Manure

Poultry statistics are not that consistent as the pig and cattle numbers used above. The South African Poultry Association (SAPA) reported a total number of 132.480.358 chickens in the broiler and egg industry in 2014. In total these chickens are reared at 804 farms across the country. However, the industry experts doubt these figures. Take for instance the Western Cape, responsible for 20% of the country's total of chickens. SAPA statistics indicate about 27 million of chickens whilst experts only estimate the total at 3 million. Considering the number of farms and average flock sizes we can assume a downward of the number of chickens and biogas production accordingly.

Table 8: Chicken manure

	Biogas (in m^3)	MWe	PJ
Theoretical potential	519.323.003	357	10,2
Feasible potential	129.830.751	89,3	2,6

Source: ARC (2016), ECN (2016), GGNL (2014)

Waste Water

The potential for biogas production by waste water treatment works (WWTW) is probably the most studied and mapped in South Africa. In the second half of the twentieth century in parallel with the introduction of AD, the South African water industry has protected its water resources very carefully and developed recycling processes because of a water shortage and a rapidly growing population. Some of the most advanced sewage treatment processes have been developed in this country and are applied globally. However, due to lack of investments, maintenance and an increase of accessibility and usage of water services after the Apartheid era the infrastructure is seriously obsolete and unable to meet the demand.

Wastewater services delivery is performed by 152 Water Services Authorities (WSA) in South Africa via an infrastructure network comprising of 824 wastewater collector and treatment systems. The South African municipal water and wastewater sector is characterised by six metropolitan municipalities, 46 district municipalities and 231 local municipalities. The majority of the WWTW are owned by municipalities.

Based upon the recent feedstock data of the bioEnergy Atlas the total of municipal waste water represents an energetic value of 22,8 PJ. Applying a 19,734 MJ/m^3 biogas as a ratio the potential biogas production would be more than 1 billion M^3 biogas. In terms of electricity this would mean 210 MWe (5,5 kWe/m^3 biogas).

However, only a part of this volume is technically and economically feasible for energy production A recent study of WEC Projects at the request of GIZ assessed the biogas potential of South African WWTWs[24]. The study has been limited to those plants having a capacity of minimal 10 ML/day resulting in a total of 129 plants in scope of this exercise. WEC has found that these plants have a potential of 27,1 MWe, which equals to 149.298 m^3 of biogas. Not surprisingly, the majority of these plants are in urbanized areas, Johannesburg, Pretoria, Durban, Port Elizabeth and Cape Town.

This volume is in line when we run a bottom up calculation, starting with feedstock data and using ECN ratio.[25] About 12% of the potential, 135 M m^3 is economically feasible for producing biogas and converting it into electricity (25 MWe). There are also other

24 WEC, GIZ, Biogas Potential, A Survey of South African Wastewater Treatments Works, June 2016.

25 See appendix.

opportunities to unlock the potential of remainder waste water streams. These could be co-digestion with other wet waste streams.

Table 9: Municipal waste water

	Biogas (in m^3)	MWe	PJ
Theoretical potential	1.155.366	210,1	22,8
Total Existing Infrastructure CHP potential WWTW	183.530	126,2	3,6
Total sewage CHP Potential (>10 Ml/d)	337.535	232,1	6,7
Total Feasible CHP potential l(>10 ML/day)	149.298	102,6	2,9
Total Feasible CHP potential (>10 ML/day) ECN data	135.231	93	2,7

Sources: GIZ (2016), Bioenergy atlas (2016), ECN (2016)

Since the WWTW with a capacity less than 10 ML/day were out of scope of the WEC study (not considered economical feasible) there might be a potential to collect sludge of smaller WTWW and combine them with other local waste streams to co-digest. Another option could be to create hubs for various streams to benefit from economies of scale. These options are subject to further study.

Kitchen, Garden waste

Municipal solid waste (MSW) typically has an organic content of between 14% and 39% (Department of Environmental Affairs, 2012). Most organic waste is still generally landfilled. Hence, the organic component in South Africa is estimated to be close to 35%. In some municipalities garden waste has been collected separately for a number of years. It is usually chipped and then composted by a private contractor appointed by the municipality. Although solid numbers are missing, experts indicate 50% of the MSW is disposed, for example, informal settlements (townships) are not serviced.

According to the BioEnergy Atlas the theoretically available organic fraction of MSW has an energy equivalent of 58,23 PJ. Bearing in mind the urbanisation rate, distribution of income, and the (lack of) waste collection process, the actual potential to produce energy is a fraction of this volume. The waste roadmap study composed by CSIR (2014) shows that about 3.000 kTon of organic MSW is generated (scenario 1, baseline). [26] In that study it is assumed that 35% is recycled, so the additional potential for biogas production could be ca 2.000 kTon. Applying the conversion ratio for biogas production and electricity generation this equals a 147M m^3 biogas/ 101 MWe.

Table 10: MSW, Kitchen, garden waste

	Biogas (in m^3)	MWe	PJ
Theoretical potential	2.949.224.688	2.028	58,23
Feasible potential	147.400.500	101	2,9

Source: BioEnergy Atlas (2016), CSIR (2014), ECN (2016)

Sugarcane

There are 14 sugar mills operating in South Africa, owned by six companies. Most of the sugar cane production is located in KwaZulu-Natal in the East. The mills operate for approximately 36 weeks of the year between April and December. Data regarding the amount of sugar cane crushed annually by each of the 14 mills has been obtained from the South African Sugar Association (SASA) website. For the 2014/2015 production season an estimate of 17,76 million tons of sugarcane has been crushed. The amount of solid and liquid waste generated from sugar cane is calculated from the total sugar cane crushed per annum.

The main solid waste residues arising from sugar processing are bagasse and sugar filter mud/pressed cake. Bagasse residues were excluded from the calculations as they are already used as an energy source at the mills. The amount of filter mud generated was calculated as a percentage of the total sugar cane crushed which is 5% (GIZ, 2014a). Therefore, filter mud generated in 2014/2015 amounted to 0,89 million tons. Applying the organic dry matter (ODM) ratio as known for sugar beet (649 m^3/ton) results in 76.6 million m^3 biogas. This exactly equals the 5% of the total potential biogas production.

Table 11: Sugarcane

	Biogas (in m^3)	MWe	PJ
Theoretical potential	1.489.814.533	1.024	29,4
Feasible potential	76.649.496	52,7	1,5

Source: SASA (2016), GGNL (2014), ECN (2016)

Food processing and beverage

As mentioned before there seems to be an overlap between the categories under the agricultural waste category in the statistics. The bioenergy atlas therefore does not specify waste streams from food and beverages industry and abattoirs.

A bottom up calculation based on the values reported by Urban Earth Consulting show that South African waste comprises about 9 million ton of food. In 2012, food processing was counted for 27% of the waste, equalling almost to 2,5 million tons. Since a vast number of this waste is likely to be used for animal feed and fertilizer, it is assumed that 10% is feasible for energy production. This corresponds to 25 million of biogas, which is in the same range of the potential calculated by EcoMetrix.

Although there is a number of digesters operational in the sector, for example at Ceres Fruits and SAB breweries, an exact installed capacity is unknown and subject to further research.

Table 12: Food processing, beverage and abattoirs

	Biogas (in m^3)	MWe	PJ
Theoretical potential	255.150.000	175,4	5
Feasible potential	25.515.000	17,5	0,5

Source: BioEnergy Atlas (2016), Urban Earth (2013), ECN (2016)

Total waste potential

All the above feedstock and energy numbers can be added to calculate the total biogas production potential and the electricity generation from biogas. The total potential of biomass is not necessarily available for biogas production; for instance, they are also used as fertilizer or cattle feed. In addition, not all the available feedstock can be converted to energy due to logistical constraints, lack of (economies of) scale etc. Hence, we estimated an availability factor (percentage) per type of feedstock in order to calculate a feasible amount of energy generation from biogas. The total feasible biogas production based on the available feedstock is estimated to be around 660 M m^3 (454 MWe).

Considering the size of the price (20% of the total feasible production) and the lowest production costs for biogas, we advise to focus on the further development of waste water treatment facilities. While a drought is threatening South Africa and there is growing demand for water and a diminishing capacity to supply it, water quality is a key priority. Investing in the refurbishment and upgrade of these plants creating an opportunity to transform wastewater treatment plants from disposal facilities to resource recovery centres that yield clean water, nutrients and renewable energy from wastewater.

With 15% of the total estimated viable production, municipal solid waste (kitchen, garden waste) is another feasible waste stream which is currently underused. The technology to convert MSW into biogas is mature and proven. The challenge is rather in terms of logistics and security of supply of feedstock. Most Waste to Energy facilities will have a payback period of 15-20 years, and require contracts of the same duration period for the waste feedstock to attract investors. This has proven challenging in the South African context for companies that target MSW as municipalities typically have three-year contracts.

The other feedstock types can be characterized as non-municipal. These waste streams belong to individual industries and therefore need to be assessed in more depth. A general business case is difficult to build. For example, the potential of manure digestion seems to be significant in South Africa. However, it is likely that only a limited number of farms qualify for biogas production. Economies of scale, costs associating with manure handling and the expensive mono-manure technology are yet limiting factors.

Table 13: Total Potential and Feasible Biogas and Electricity Production

Feedstock	Biogas	Electricity			Percentage	Biogas	Electricity
	Total Potential	Total Potential			Feasible	Estimated Feasible	
	M3	**MWh**	**MWe**	**PJ**	**%**	**M3**	**MWe**
Agricultural	150.010.985	825.060	103	3,0	75%	112.508.239	77,3
Cattle Manure	381.555.048	2.098.553	262,3	7,5	20%	76.311.010	52,5
Chicken Manure	519.323.003	2.856.277	357,0	10,2	25%	129.830.751	89,3
Food, Beverage (processing)	255.150.000	1.403.325	175,4	5,0	10%	25.515.000	17,5
Kitchen, Garden Waste	147.400.500	810.703	101,3	2,9	67%	98.758.335	67,9
Pig Manure	25.051.704	137.784	17,2	0,5	20%	5.010.341	3,4
Sugarcane (bagasse)	76.649.496	421.572	52,7	1,5	100%	76.649.496	52,7
Waste water	135.230.721	743.769	93,0	2,7	100%	135.230.721	93
Total	**1.690.371.457**	**9.297.043**	**1.162,1**	**33,4**	**43%**	**659.813.893,0**	**453,6**

Source: ECN (2016)

5

Recommendations

The potential for electricity generation from biogas of various organic waste sources in South Africa is estimated at ca 0,9 GW. However, this potential may be well off. Considering the availability of feedstock, logistical costs and the costs of technology for some waste streams 0,45 GW seems to be feasible to further development. To put this number into perspective, it equals 2,5% of the the renewable energy target in 2030[27].

Invest in Waste Water Treatment Works

The sewerage sludge produced by the municipal Waste Water Treatment Works has a significant potential to be converted into biogas and to provide a portion of the electricity required by the WWTW. A total of 93 MWe electricity generation (19% of the total potential) can be considered as realistic in the medium term. Since this feedstock is the cheapest feedstock to process and often located in urban areas, this potential can be marked as a low hanging fruit.

However, most WWTW in SA are currently facing significant operational challenges of which sludge management is a major issue. Large scale investment in a program of WWTW refurbishments, including fully operational biogas CHP plants, could play a major role not only in increasing efficiency of WWTW, but also in reducing overhead costs by supplying own generated electricity.

A recent business case for refurbishment of the Cape Flats facility near Cape Town, one of the biggest plants in South Africa, shows that an upgrade comes with a costs of R 0,30 per kWh (€ 0,02). In this case an installed CHP capacity of 2.5 MWe would already generate about 12 MW.

Public tenders Waste to energy

South Africa's municipal waste sector has an enormous energy potential. However, project developers have been experiencing extreme difficulties in accessing to the municipal waste streams. An important stumbling block for municipalities is the Municipal Finance Management Act (Act No. 56 of 2003, MFMA and its amendments in 2005). A limitation to a contracting period of 3 years is often a showstopper for a

[27] Department of Energy (2015), State of Renewable Energy

bankable business case. There is a workaround, a so called exemption on the MFMA, but this procedure is not standard and often results in long delays. The advice would be to align tender policy and concession periods of waste collection with decentralized energy production and offtake.

Legal framework and ruling for projects under 1 MW

One of the main perceived barriers to development of the biogas sector in South Africa is the limitation on revenues. Projects below 1 MW capacity are not allowed to connect or sell electricity to the national grid. It should be noted, however, that a large number of these projects will use the generated electricity for own consumption.

South African state utility Eskom, and the only licensed buyer and distributor of energy, must purchase at least 1 MW of capacity from any IPP while the vast majority of the project development is in this segment (<1 MW) (See table 4). In 2012, South African utility Eskom has added a rebate for small-scale renewable energy projects in the commercial/industrial sector under its Integrated Demand Management (IDM). The rebate (R 1,20 per kWh) was only offered for a three-year period. Unfortunately, due to significant financial constraints experienced by Eskom, the programme was placed on hold.

It is recommended that the DoE takes the lead and engages with SABIA, Eskom and others to work out a legal framework for this specific segment. Options like net metering and a feed-in tariff (FIT) are subject to further research.

Business case

Biogas projects often struggle to present a sound business case. Especially, those projects with more expensive biomass feedstock as a result of pre-treatment and/or logistic costs have difficulties to present a bankable business case.

Although the latest tariff of R 1,47 per kWh (€ 0,15) as offered in the last REIPPP round is considered a major step forward, this level does not monetize the base load capacity of biogas. From conversations with the project developers and market players it has emerged that a tariff close to R 2,00 per kWh would make (more) projects feasible.

A pricing model that takes the advantages of base load power into account is a two-tier pricing structure. For example, the dispatchability potential of Concentrated Solar Power (CSP) in South Africa is rewarded with a higher tariff during peak demand from 16h30-21h30. Unfortunately, recent developments show that CSP projects under the REIPPP are facing resistance because of a tariff discussion. As a result, it seems this two-tier pricing model is abandoned.

To further boost biogas development, SABIA is now working on a bonus scheme for biogas projects. The sector has agreed on a standard measurement unit of biogas based on gas composition and energy content (MJ / Nm^3).

It is expected that this proposal will be presented to DOE early next year. Especially for projects using manure as feedstock, it is worthwhile to consider a compensation for the avoided methane emissions.

Based upon the Dutch experience, a tariff in the range of R 1 – 1,50 per kWh (€ 0,18-0,27 per m^3) should be sufficient for the biogas from WWTW and MSW. Note, however, the costs of capital in South Africa are significantly higher. On that note, international climate funds can play a role to leverage private capital investment and provide bonds at a lower rate.

Regulations on waste, environment and air quality

Regulations and related licences are also regularly mentioned as barriers to the implementation of biogas projects. South Africa has a strong regulative and legislative environment especially on the environment sector. SABIA is frequently in consultation with the Department of Environmental Affairs streamlining regulations on waste and biogas. Awaiting a dedicated legal framework for biogas development, it would be helpful for developers to get a regular update and overview of the relevant legislative adaptations. Minimizing the red tape and single governmental ownership should be a top priority. Already heavily involved in the biogas sector, The South African National Energy Development Institute (SANEDI) could act as an administrative agency ("one-stop shop").

In short:

- Invest in Waste Water Treatment Works, 20% of potential production and cheapest way to produce biogas
- Explore the opportunity of International Climate Funds offer to finance biogas projects
- Align duration waste and energy tenders, the MFMA
- Introduce a legal framework and ruling for < 1 MW projects
- Consider alternative pricing models biogas, taking base-load function and avoided methane emissions into account
- Introduce a dedicated legal (environmental) framework for biogas
- Minimize the red tape and and single governmental ownership, e.g. SANEDI.

Appendix A. Biogas projects

Table 14: List of commercial biogas projects in South Africa

Project	Location	Province	Feedstock	Capacity
Bio2watt / Bronkhorst- spruit Biogas Plant	Pretoria	Gauteng	Manure	4,6MW
BiogasSA / Morgan Springs Abattoir	Springs	Gauteng	Slaughter waste and organic waste	0,4MW
BioTherm SA, Mossel Bay PetroSA	Mossel Bay	Western Cape	Refinery waste water	4,2MW
Bisasar Road LFG	Durban	Kwazulu Natal	3500-5000 tons refuse per day	6MW
CAE / Humphries Boerdery Piggery	Bela-Bela	Limpopo	Pig manure	na
CAE / Uilenkraal Dairy Farm	Darling - Uilenkraal	Western Cape	Bovine manure	600 kW
CAE / University of Fort Hare	Alice	Eastern Cape	4000 m^3 of dairy and piggery manure	2x132kVa generators
Drakenstein Municipality	Paarl	Western Cape	Municipal waste	2 MW/ 10-12 MW
Elgin Fruit and Juices	Grabouw	Western Cape	> 5 tons of fruit waste per day	500 kW
Farmsecure	Klipheuwel (Zandam)	Western Cape	> 5 tons of manure per day	600-700 kW
FarmSecure Carbon	Bonnievale	Western Cape	>5 tons bovine manure	na
FarmSecure Energy	Darling - GrootPost	Western Cape	Bovine manure	na
FarmSecure Energy, Wastemart, CEA / New Horizon waste to energy	Athlone Industria	Western Cape	±400 tons of organic waste per day	na
iBert	Queenstown	Eastern Cape	42 tons mixed waste from a piggery per day	na
iBert	Cavalier	Gauteng	20 tons abattoir waste per day	~500kw
iBert	Jan Kempdorp	Northern Cape	5,5 tons abattoir waste per day	~135kw
iBert	Bredasdorp	Western Cape	4 tons abattoir waste per day	~100kw
iBert	Riverdale	Western Cape	4 tons abattoir waste per day	~100kw
Jeffares & Green / Bayside Mall	Table View	Western Cape	0,6 - 1 ton of food waste per day	na
Mariannhill LFG	Durban	Kwazulu Natal	550-850 tons refuse per day	1,5MW
Reliance Composting	Klipheuwel	Western Cape	~700 tons organic waste per day	na
Rhodes Food Group	Stellenbosch / Franschhoek	Western Cape	35kg per day (testing feedstock)	na
SAB Miller	Newlands	Western Cape	4500m^3 of wastewater per day	10% of the plants energy demand
Selectra	Unknown	Unknown	Sewage, silage, manure	0,5MW
Selectra	Unknown	Unknown	Sewage, silage, manure	1MW
Selectra	Unknown	Unknown	Sewage, silage, agri waste	1MW
Veolia Water Technologies/Distel	Stellenbosch	Western Cape	1000m^3 wastewater per day	na
WEC / Northern Waste Water Treatment Works	Johannesburg	Gauteng	Sewage sludge	1,2MW
WWTW Belville	Belville	Western Cape	Wastewater Treatment Plant	na
Total				37 - 50 MW

Table 15: Key ratio feedstock

Feedstock		Organic Dry Matter odm kg/ton	N-tot kg/ton ws	CH4 %	Biogas Nm3 biogas/ ton odm	Biogas Nm3 biogas/ ws
Agricultural		na	na	na	na	na
Cattle Manure	Liquid	68,0	4,5	56,0	320,0	21,8
	Solid	200,0	4,0	55,0	450,0	90,0
Chicken Manure	Solid	392,0	24,1	58,0	500,0	196,0
Food, Beverage (processing)		150,0		60,0	700,0	302,0
Kitchen, Garden Waste		200,0	30,0	60,0	375,0	75,0
Pig Manure	Liquid	61,0	7,2	60,0	300,0	18,3
	Solid	230,0	7,5	60,0	400,0	92,0
Sugarcane (bagasse)		133,0	5,0		649,0	86,0
Waste water		35,0	1,4	63,0	350,0	12,3

Source: GGNL (2014)

Table 16: Key ratio Biogas

Biogas	
1 m^3	55% CH_4
1 m^3	5,5 kWh
1 m^3	19,734 MJ

Source: GGNL (2014)

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