

Biogas potential in selected waste water treatment plants

Results from scoping studies in nine municipalities



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1. Background

1.1. Introduction

South Africa has high potential for renewable energy exploitation and has set itself the target of 17.8 GW of new renewable energy generation capacities to be installed by 2030. The stimulation of the renewable energy industry in South Africa will contribute to this target as well as to sound socio-economic development, job creation and a growth path that is both environmentally friendly and sustainable. Amongst other efforts to promote renewable energy development, the country has committed to scaling up the recovery of energy from waste in order to meet the 2030 target. Since the Constitution stipulates that municipalities are responsible for waste service provision, they have an important role to play in harnessing waste for energy purposes.

The South African Local Government Association (SALGA) and the South African-German Energy Programme (SAGEN), implemented by GIZ, have entered into an agreement to promote renewable energy at the local level of government. The collaboration aims to strengthen local governments' capacity to implement renewable energy projects and to fast-track the facilitation of such projects within their areas of jurisdiction.

The generation of electricity from waste, in particular through biogas, was selected as a priority by SALGA/GIZ due to a number of comparative advantages including:

- The ability to provide base-load or peak power to the distribution grids;
- High job-creation potential/linkages to sustainable rural development (particularly with agricultural waste);
- The possibility of using existing infrastructure (generation) and services (supply);
- The potential to reduce municipal organic waste in an environmentally friendly manner;
- The overall positive impact on municipalities' expenditures (electricity);
- The reduction of greenhouse gases emission from the methane emission naturally occurring in landfills or in some digesters.

GIZ/SALGA have thus decided to conduct studies to promote the large scale rollout of biogas projects by identifying the biogas potential in South African municipalities along with their barriers and challenges

(financial, regulatory, technology, etc).. As part of these efforts, GIZ and SALGA commissioned studies to identify the biogas potential in nine selected municipalities. This report summarises the results of these studies, with a view to sharing the information gathered with relevant stakeholders in the sector. It describes general findings about biogas projects in waste water treatment works that can provide guidance to stakeholders on the viability of such projects.

1.2. Objectives

The objective of the studies was to assess the potential for the development of viable anaerobic digestion projects at nine selected pilot municipalities. Of the nine municipalities, the most promising municipalities were selected to undergo more detailed pre-feasibility studies, which will further assess their viability by confirming the potentials anticipated and by studying the most appropriate financial and project ownership models, applicable regulatory requirements, as well as the status of the existing municipal infrastructures.

If some projects are found to be viable, GIZ and SALGA might consider supporting the municipality with project development. There is, however, no intention by GIZ and SALGA to fund any projects since the financial viability of biogas projects must be such that they can be replicated in other municipalities without relying on outside donor support.

In addition, the implementation of these studies provided an opportunity to employ a practical "learning by doing" approach to project design that identified real-world opportunities and barriers to the implementation of such projects. Such hands-on lessons could thereby lay the ground work for the establishment of projects and hence offer an approach with enduring benefits that could be applied in the long run. GIZ and SALGA will use the findings of these studies to address the identified barriers with relevant national departments and relevant stakeholders, in order to advance an enabling environment for renewable energy projects in municipalities.

1.3. What is biogas and anaerobic digestion and how is it applicable to municipalities?

Anaerobic digestion is not a new technology and has been widely applied for the treatment of organic waste for over a century. However, only recently has it been considered for application in South Africa for treating sewage sludge, agricultural wastes or other organic waste in order to generate renewable energy and divert waste from landfill. Anaerobic digestion is a natural process in which micro-organisms break down organic matter (such as food wastes, slurry, crop residues, etc) into biogas and digestate in the absence of oxygen in a decomposition process. Biogas is a methane-rich mixture comprising 25% – 50% carbon dioxide (CO₂) and 50% – 75% methane (CH₄). The digestate can be used as a bio-fertiliser.

Typical feedstocks include:

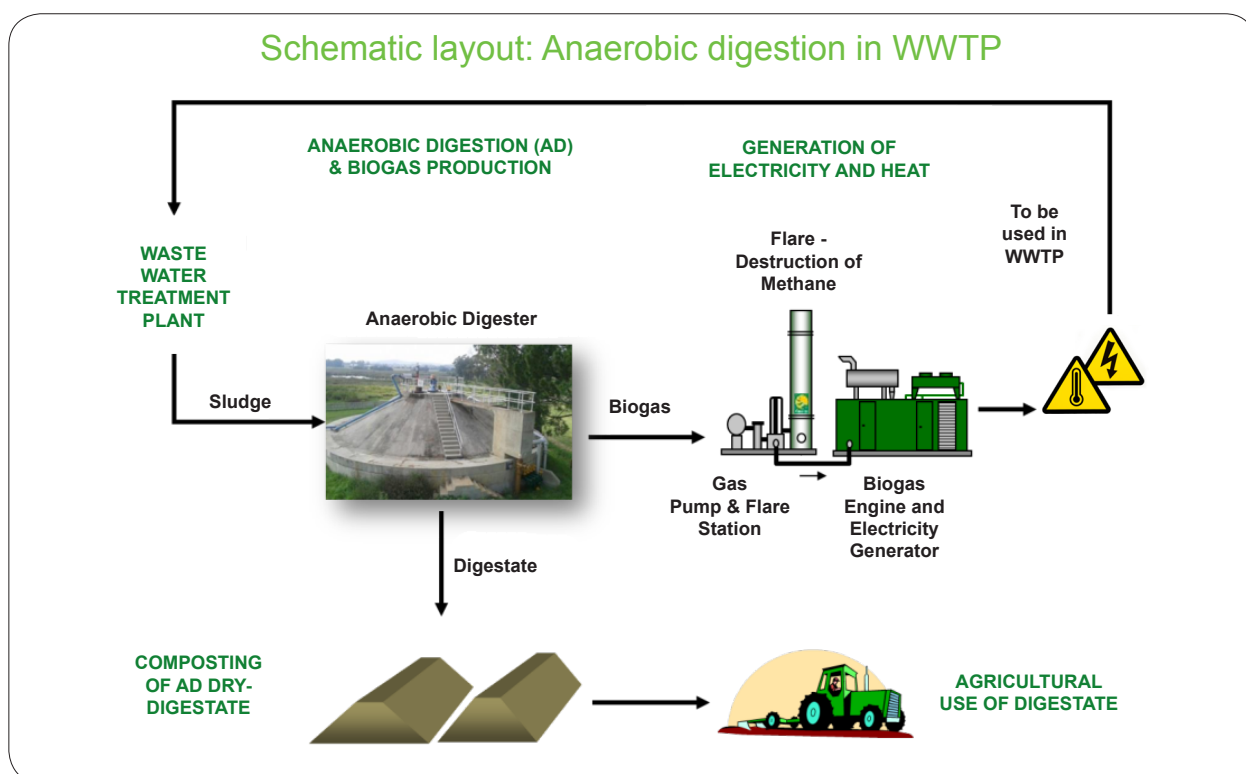
- **Sewerage:** domestic, municipal, schools, hotels, etc;
- **Food waste:** domestic & industrial/commercial, including fats and oils;
- **Manure:** pig, cattle - dairy or feedlot, chicken, etc.;

- **Agricultural:** vegetables, fruit, maize, sugar cane, etc ;
- **Commercial:** abattoirs, cheese factories, breweries, wine estates, processing plants, fruit and vegetable packaging plants.

The biogas can be used in a number of ways:

- directly in engines for electricity generation and possibly in a Combined Heat and Power (CHP) engines, producing both electricity and heat;
- burned to produce heat (which could also produce steam);
- cleaned/scrubbed to become bio-methane and used in the same way as natural gas for cooking, lighting or as a vehicle fuel.

The digestate/biofertiliser, which is produced by the biological processes, contains valuable chemical nutrients such as nitrogen and potassium, and can be used as an organic and renewable fertiliser or soil conditioner.



Source: Modified by SALGA¹; photo of the anaerobic digester by Mark Tiepelt (Biogas SA), taken at Tlokwe WWTP.

¹ Evaluation of the Waste-to-Energy (WtE) Potential (Biogas to Electricity, Anaerobic Digestion) in Five Selected Municipalities, SLR Consulting South Africa

1.4. The nine selected municipalities

A circular was developed and sent by SALGA to all municipalities via SALGA provincial offices calling for expressions of interest in the project. Five municipalities were selected through this process; four additional municipalities were selected via consultations with the SALGA provincial offices.

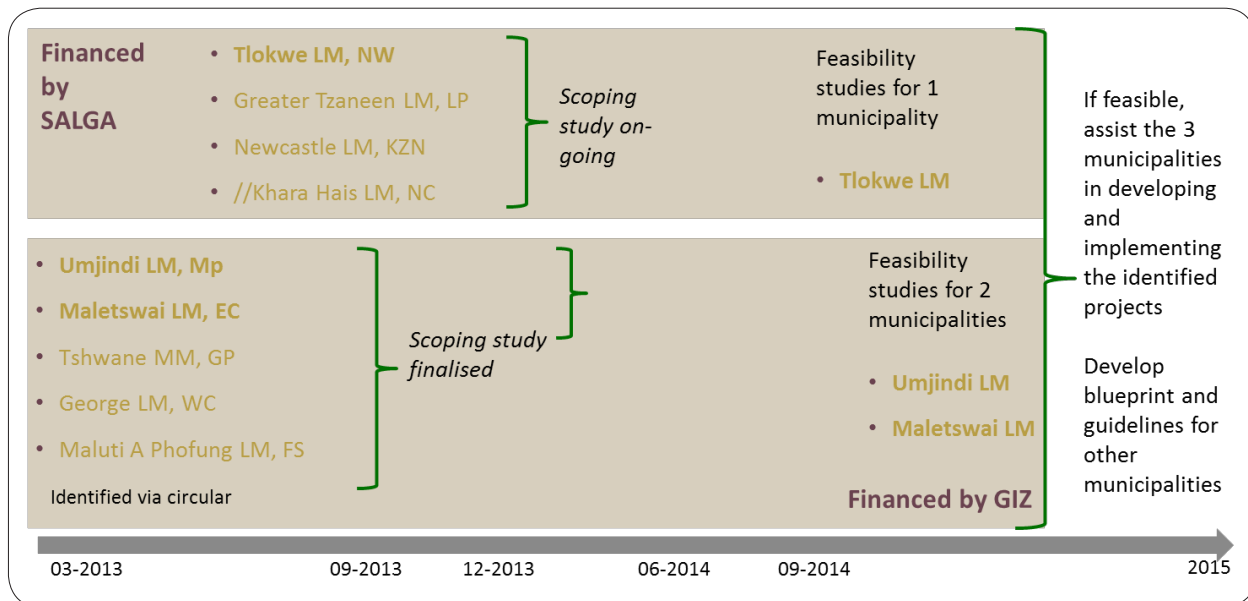
The following nine municipalities across South Africa were selected:

1. City of Tshwane Metropolitan Municipality – Gauteng Province
2. Maletswai Local Municipality – Eastern Cape
3. Maluti A Phofung Local Municipality – Free State
4. Umjindi Local Municipality – Mpumalanga
5. George Local Municipality – Western Cape

6. Tlokwe Local Municipality – North West
7. Newcastle Local Municipality – KwaZulu-Natal
8. Greater Tzaneen Local Municipality – Limpopo
9. //Khara Hais Local Municipality – Northern Cape

The study for Tshwane, Maletswai, Maluti A Phofung, Umjindi and George was financed by GIZ and conducted by SLR Consulting. The study took place from August 2013 to November 2013.

The lessons learnt and conclusions from this first study were used during the second study in the remaining four municipalities: Tlokwe, Newcastle, Greater Tzaneen, and //Khara Hais. This study was financed by SALGA and conducted by Biogas SA between February 2014 and July 2014.



Overall timeline of the studies, by SALGA and GIZ.

2. Methodology and general results

2.1. The assessment process / key areas studied

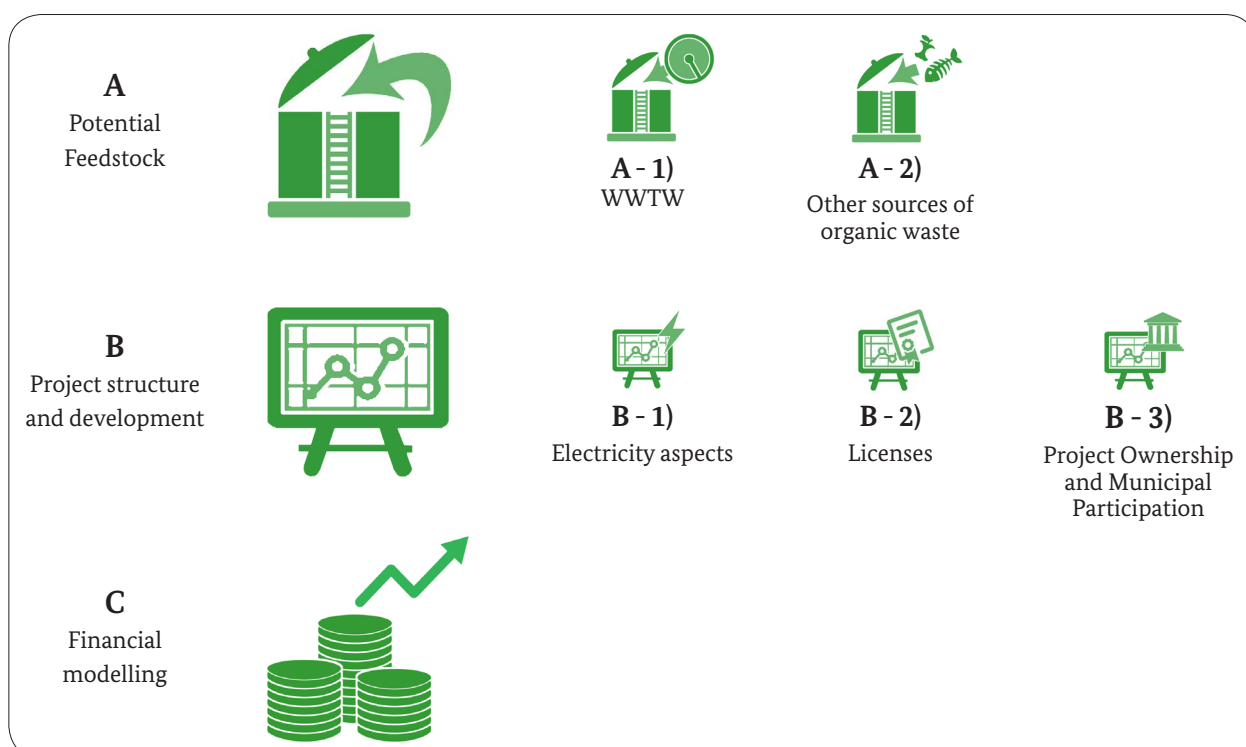
The studies focussed on a scenario where the biogas plant is located at the Waste Water Treatment Works (WWTW) with the sludge produced by the WWTW being the primary feedstock to be converted into biogas and subsequently into electricity. The municipality thus remains the embedded generator and therefore operates as the project owner and/or developer.

The study also looked at the viability of securing additional organic feedstock over and above the sludge from the WWTW, including organic waste directly collected by the municipality, such as the organic waste fraction of Municipal Solid Waste (MSW). The viability of collecting/sourcing additional organic waste from other sources within the municipal area (agricultural, commercial or industrial) has also been investigated. Typical farming operations that have been considered for the sourcing of additional biomass were fruit and vegetable farmers, fruit and vegetable packaging operations, dairies, piggeries, chicken farms, feedlots, vineyards and any other farming operation that produces substantial quantities of organic waste.

The study identified several farmers where stand-alone biogas projects could prove viable. However, this was not studied in more detail as the focus of the study was municipal biogas production. Farms could use the electricity produced for own-use on the farm and would thus not necessarily involve municipalities. Note that, in principle, the signing of a Power Purchase Agreement (PPA) between farms producing the electricity from biogas and municipalities buying it could be an option; however, this was not covered by the studies.

Assessments on viability were primarily determined by the anticipated Return on Investment (ROI) calculated by comparing the cost of establishing a biogas plant in relation to the potential income generated from replacing electricity bought from Eskom. Other indirect benefits such as efficient waste management, reduction in sludge, carbon mitigation, job creation potential and skills transfer could further enhance viability.

The following areas were studied for each municipality:



2.2. General results from the studies



A - 1) Waste Water Treatment Works (WWTW)

The studies commenced with an assessment of the potential quantity of sludge available at WWTWs as this is a primary determinant of project viability. It was also critical to understand the water treatment process employed by the various WWTWs to better understand the current and future potential to produce biogas. Detailed assessments of WWTWs informed the design and selection of the methodology to be followed to evaluate the biogas potential in WWTW. Each municipal WWTW has a unique water treatment process, which leads to highly variable biogas yields, which could be substantially different from a theoretical calculation based solely on the inflow of waste water in the WWTW. It is thus very important to understand in detail the waste water treatment processes and such expertise should be included in the project team of any biogas project in WWTW.

The following information was identified as key to assess the potential to produce biogas:

- Design capacity and current flows
- Plant operational process
- Sludge generation process
- Current quantity of sludge produced
- Current quantity of biogas produced, if any

- Existing biogas capture infrastructure, if any
- Sludge disposal procedures
- Status of existing digesters (number, size, mixed and/or heated, structural integrity, etc.)

The information required to perform a full analysis is usually only partially available from WWTW managers since typically WWTWs mainly monitor the inflow of waste water and the quality of the water released at the end of the process, which is the core function of a WWTW.

It is worth noting that even though all the WWTWs analysed in this study have digesters, these are operated to optimise sludge management and not to optimise biogas production. Sludge management is integrally part of the operations of the WWTW and most municipalities have drying beds which function with varying degrees of success. There normally exists some arrangement with the private sector to collect the dried sludge that is then used as compost. Fully functional digesters will benefit the WWTW by reducing the quantity of sludge going to the drying beds and improve its quality for organic composting. There are new regulations currently under development that will specify improved sludge management in the future.



A - 2) Additional Organic Waste

As part of the study, information was collected on municipal solid waste, which consists of organic and in-organic material. A potential co-digestion plant could only benefit from the organic fraction of municipal solid waste. Points taken into consideration were:

- What quantity of solid waste is currently being collected?
- What percentage of solid waste is organic?
- Is any separation being done, either at source or at landfill?

- If no waste separation is being done, what are the governing factors that are holding the municipality back from implementing waste separation? It should be noted that without waste separation, the use of waste in anaerobic digesters is impossible.
- Does the municipality have a Municipal Recovery Facility (MRF) separating organic components or plan to have one installed in the near future?
- Is it possible to obtain well separated, high-energy, organic waste such as that from grease traps in restaurants?

The technical feasibility of mixing the organic fraction of the municipal solid waste with the sludge for successful anaerobic digestion is also an issue since the treatment of municipal organic waste is usually done in so-called dry anaerobic digesters. Mixing different kinds of substrates leads to different biogas yields because some organic waste is suitable for treatment in dry anaerobic conditions while sludge should be treated in wet conditions; the relative combination of the two will influence the amount of gas that can be produced. (See table 2 in the Annex for indications of what is suitable for mixing with sludge.) Organic sources which might be suitable for co-digestion might come from large “pure” industrial producers or grease traps.

Shopping malls, hospitals, hostels, restaurants and franchise chains, and old age homes all produce large quantities of food waste that has a high biogas yield potential and is ideally suited to complement WWTW sludge as digester feedstock.

This type of waste is normally collected by the municipality and taken to landfill as part of MSW activities, but it would be beneficial for biogas generation if municipalities collected this waste separately and directed it to the biogas plant.

A number of operations such as breweries and processed food factories produce organic waste and companies dispose of it in municipal landfills. Such waste streams which are both a cost to the companies and typically not welcomed by the municipality, could be redirected to biogas plants.

Further research in partnership with universities could be undertaken to investigate the viability of including such waste disposal processes. In particular, the University of North West in Tlokwe is currently conducting research on similar topics.

The viability of adding additional organic waste, whether from the organic fraction of municipal solid waste or any other, is primarily determined by the following factors:

- Whether the existing digesters have spare capacity,
- If no spare capacity exists, consideration of whether the cost of building additional digesters is covered by

the increased electricity revenue, determined by the amount of additional waste available,

- The feasibility of co-digesting the additional organic waste with sludge.

The main advantages of co-digestion² are:

- A stable and reliable digestion performance and a good-quality fertilizer from the digestate,
- An enhanced digestion of materials that are difficult to digest,
- A increased and more stable biogas production throughout the seasons,
- Additional fertilizer (soil conditioner).

However, feedstock for co-digestion must be carefully selected as some varieties may inhibit the generation of methane. Increased feedstock volumes may affect the retention time in the anaerobic digester – longer retention times allow the feedstocks to fully digest, which maximizes biogas production and minimizes odours. For existing anaerobic digesters, the capacity of the anaerobic digester to handle additional feedstock, as well as the capacity of the biogas system to handle the increased biogas and methane gas produced from co-digestion should be carefully considered. The mixing of liquid manures with drier feedstock materials may increase the total suspended solids (TSS) content of the digester feedstock, so it is important to maintain enough moisture to sustain anaerobic activity.³

The most common situation involves the mixing of a large volume of a main, basic substrate (e.g. sewage sludge) with smaller volumes of a single, or combination of, additional substrates. Typical co-substrate addition rates in sewage sludge digesters are between 5% --20%. Addition of flotation sludge, fat trap-contents, food leftovers, proteinaceous wastes etc., considerably raises the biogas productivity of sewage sludge digesters by 40% –200 %. A number of organic substances are anaerobically easily degradable without major pre-treatment. Among these are leachates, slops, sludge, oils, fats or whey. Some wastes (e.g. proteinaceous wastes) can form inhibiting substances (e.g. NH_3) during anaerobic digestion, which require higher dilutions with substrates like sewage sludge. A number of other waste materials often require pre-treatment steps (e.g. source-separated municipal bio-waste, food leftovers, expired food, market wastes, and harvest residues). The pre-treatment

² Braun and Wellinger (2003) and DWA (2009)

³ Source: USEPA, 2012

steps might include three basic processes: size reduction of the substrate; removal of indigestible components; hygienization.⁴

Depending on the quality and nature of the waste to be used for co-digestion and the size of the operation, some additional digester equipment may be required for achieving a reliable digestion. Additional equipment or precautions may be required for: delivery of the waste, homogenization and mixing of co-substrates, prevention of excessive foaming and scum layer formation, removal of sediments from the digester.⁵

Some substances, such as grease traps residues, flotation

sludge, food industry waste and rumen contents, require special care. The use of municipal waste without pre-treatment is not recommended due to the uncertainty of its content. Annex 1 presents different waste streams and their suitability for co-digestion in WWTW.

Given the multiple requirements needed to implement co-digestion outlined above, implementation of co-digestion activities would necessitate a separate, detailed assessment of other sources of organic waste. Co-digestion was thus not a focus of these scoping studies.



B - 1) Electricity (and Heat) Usage

The electricity produced by the biogas plant could:

- Be used on-site by the WWTW,
- Be fed into the municipal grid,
- Be sold to a consumer of electricity through an offtaker arrangement.

WWTW uses a lot of electricity, particularly for pumping and aeration purposes. If a biogas plant is located at the WWTW site, the electricity produced could be used on-site to reduce electricity consumption of the works. With sufficient electricity equipment, the biogas plant could offer security of supply in times of electricity shortage. International references show that around 60% of the electricity consumption of the WWTW can be offset by the electricity generated at the biogas plant. Modern plants that are optimized in such ways lead to 80% improvements in energy optimisation, and in cases of co-digestion rates of 100% can be reached. Hence a strong case can be made for implementing energy efficiency measures at WWTWs in order to reduce electricity demand and costs by, for example, enhancing pumping operations, pumping equipment, optimisation of processes and aeration equipment.

The price of electricity paid by WWTWs differs from one municipality to the other and can be substantially above

the average megaflex tariff paid by the municipality to Eskom. This increases the financial viability of the project. The tariff structure (Time-of-Use or flat rate) also has an impact on the financial viability of a biogas plant. This would need to be assessed on a case-by-case basis. However, such an investigation would be impeded by the fact that some municipalities do not keep records of their electricity consumption and because accessing reliable information is difficult.

On-site consumption of electricity is preferable to feeding the electricity into the municipal grid.. Moreover, since the electricity consumed by the WWTW is normally higher than the electricity potentially produced from the biogas generated, no excess electricity would be available for sale to the grid.

Selling to the private sector would be attractive for a WWTW only if the buyer is willing to buy electricity at a premium price that is higher than the price the WWTW pays for its own electricity. This could, for example, be the case if the buyer wants to promote its green profile. Such an option is however complicated and costly as long-term commitments have to be negotiated between the WWTW and the buyer as part of a Power Purchase Agreement and wheeling arrangements to transport the electricity to the

⁴ Source: Braun and Wellinger, 2003

⁵ Source: Ibid

buyer must be concluded with the owner of the grid which comes with additional costs.

The heat produced by a combined heat and power (CHP)

unit should also be used on-site, mainly to heat the digesters and thereby increasing the biogas production. It could also be used for drying the sludge in order to produce fertilizer.



B - 2) Licenses

The licensing requirements for a biogas project in a municipal waste water treatment plant are not clearly stipulated under current legislation and further research is needed to elucidate them. Ideally a pilot project should be implemented to fully understand the implications of the legislation. The broad categories of legislation that could have a bearing on biogas at WWTW can be summarised as follows:

- **The licensing requirement of the WWTW itself:** In the case of an existing, legally registered WWTW, the impact on the licenses and permits of introducing a biogas plant still has to be determined. Various laws will need to be taken into account, among others, the National Environmental Management Act and the National Water Act.
- **Environmental Impact Assessment (EIA):** In the terms of National Environmental Management Act (No. 107 of 1998), projects may be subject to a Basic Assessment or to Scoping and Environmental Impact Reporting,

the latter often being referred to as a “Full EIA”. The choice between Basic Assessment and Full EIA depends on the scale and design of the existing WWTW facility, on the scale and design of the biogas digester, and on the existing licenses.

- **Various authorisations:** Waste Management License; Water Use License, Atmospheric Emission License; Land Use Planning Authorisation; Major Hazard Installation Regulations may also be relevant.
- **Electricity-related authorisation:** While a generating license from NERSA is usually only required if the project sells the electricity into the national grid, biogas is an exception Section 28 of the Gas Act No. 48 of 2001 stipulates that NERSA registers all small biogas projects not connected to the grid.

This topic requires further studies based on specific case studies or pilot projects.



B - 3) Project Ownership and municipal participation

The ownership model of the project plays a critical role in viability of a biogas plant. The first option will always be for the municipality to retain full ownership, not only of the actual plant, but also of all the waste streams sourced for the project. With municipal ownership the project will not require any of the following: a Public Private Partnership (PPP), a PPA, a generating license and a wheeling agreement. Therefore the entire process of establishing a biogas plant will be simplified and the time required to formalise contracts and agreements will be reduced. Such streamlining of the project preparation process could also increase the ROI. However, if ownership is retained by the

municipalities, ascertaining the roles and responsibilities of those in charge of operation and maintenance of the plant is paramount to ensure sustainability of the project. This is another aspect that requires further investigation at feasibility study stage.

Private participation in the project may be helpful in order to bring in specific project development expertise or to mobilise private capital. However, the private sector may only be interested if the ROI is high enough to make it attractive to invest. Such projects may be set up as a PPP or on an approach whereby an energy service company

(ESCO) provides turnkey services or is contracted for engineering planning.

Due to the fact that biogas is a relatively unknown technology in South Africa and will be new to most decision makers within the municipalities, the development of a municipal biogas project will require the appointment of a dedicated champion within the municipality to drive the project to final implementation. Over and above the dedicated champion, it will be advisable for municipalities to set-up cross-de-

partmental teams to steer the implementation of the project and appoint consultants with the necessary experience in the biogas field to accurately evaluate the potential and to draft the necessary tender documentation. This is particularly important as biogas projects are influenced by many variables, and generic solutions and specifications would be too limited. This presents a significant challenge in the formulation of tender documents that are concise and specific enough to ensure a successful biogas plant.



C - Financial Modelling

The primary factor that determines the financial viability of a project is the potential income that can be derived from the electricity generated from the available biogas. This can be based on actual revenues from selling the electricity or, more likely, on cost savings from avoided electricity purchases in those instances where it is consumed on site.

Secondary benefits include free thermal energy that is a by-product that can be captured from running a CHP unit as well as a reduction in the amount of sludge produced and its associated benefits. These benefits are, however, not always easily quantifiable in financial terms. The municipality could also add a value on the potential to create new job opportunities as a result of implementing such a project, as well as the effect of carbon mitigation associated with preventing methane emissions.

The financial model chosen for a particular project will depend on whether the municipality remains the sole project owner or whether a PPP is created with private sector participation. The necessary degree of profitability will differ based on owner expectation, i.e. municipal versus private sector. Private sector stakeholders as part of a PPP may require a higher ROI compared to the municipality retaining sole ownership.

Establishing a PPP would have advantages for the municipalities in mobilising expertise, sharing risks and reducing

financial commitment. But municipalities are also aware that establishing a PPP can be a lengthy, cumbersome and costly process. A PPP will also require securing a PPA, either directly with the municipality or with a third party such as a large private sector electricity consuming company. Drawing up a PPA will require a comprehensive contract that again presents a cost and time factor, particularly if a wheeling agreement is required.⁶

In general, biogas projects will require a long-term investment of 7-10 years or more. The first results from the studies indicate that there seems to be a definite viability to implement projects at larger WWTW, specifically where the inflow is in excess of 15ML/day.

A WWTW with a flow of less than 15ML/day would most likely not be able to produce sludge in sufficient quantities to prove financial viability based upon the amount of electricity it could generate. It was, however, also found that even WWTWs with flows of higher than 15ML/day could in fact produce less than viable quantities of sludge due to the specific waste water treatment processes implemented by those works. The actual processes employed by WWTW therefore play a critical role in determining project viability.

For specific WWTWs, additional modelling will always be necessary to confirm these numbers and estimations.

⁶ A wheeling agreement is required for the right to use the electricity grid to transport electricity from where it is produced to where it is consumed. For example, if the WWTW is situated within a municipal grid and the buyer is situated in the same grid, the municipal grid operator may charge for transporting the electricity based on a wheeling arrangement. If the buyer is situated within an Eskom grid, an additional wheeling agreement will have to be signed with ESKOM for the right to use the ESKOM-owned electricity grid.

3. Specific results for each municipality (summary)

The following section outlines the WWTWs in each of the nine municipalities that were studied and their associated electricity potential. In the course of the investigation, additional information was collected on municipal solid

waste and other potential organic waste sources in the municipal area. This additional information is presented here, even though the electricity generation aspect was only analysed for the WWTWs.

3.1. City of Tshwane Metropolitan Municipality – Gauteng Province



A - 1) Waste Water Treatment Works (WWTW)

There are currently 15 WWTWs owned and operated by the City of Tshwane that primarily use the activated sludge process, with a combined treatment of 495ML/day, and 21 privately owned and operated plants. The WWTW are generally in good operating condition, although some of the WWTW are at 90% capacity and in need of an upgrade.

The City of Tshwane's officials highlighted that their greatest current need is sludge management. A biogas

project could decrease the quantity of sludge produced, while increasing its quality, thus assisting the municipality in solving its sludge management issue. A comprehensive city-wide strategy would assist in this regard.

The largest WWTW is the Rooiwal works which currently processes 220 ML/day with plans in place to upgrade this to process a total of 300 ML/day. Currently this WWTW could yield an electrical generation potential of approximately 4MWe.



Digesters at Sunderland Ridge WWTW



A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste:

Solid waste is currently disposed in 8 operating landfill sites, with 2 landfills that are due to be closed soon. A total

of 3,000,000 tons of waste is currently sent to landfill across the municipality. There are also 10 dedicated garden refuse sites within the municipality. Additionally, there is a large amount of purely organic waste produced by the Tshwane Fresh Produce market within the municipality.



C - Financial Modelling

There is undoubtedly large potential for the implementation of a biogas project within the City of Tshwane. This is primarily owed to the large volumes of sludge handled by the WWTW and a biogas plant would therefore minimise its sludge management challenges.

Future detailed planning by the City of Tshwane should provide focus on the city's renewable energy priorities and future infrastructure planning around organic waste feedstock.

3.2. Maletswai Local Municipality - Eastern Cape



A - 1) Waste Water Treatment Works (WWTW)

The municipality is serviced by two WWTW: Aliwal North and Jamestown, processing 4.9 and 0.9 ML/day respectively. The Aliwal North WWTW comprises two systems: an older activated sludge system and a newer raceway system, both based on the Modified Ludzack Ettinger plant. The overall capacity of the works is 5.5ML/day. The current inflow (average of 4.9ML/d) is split allowing for each system to receive half of the inflow volume.

The primary sludge is treated using the return activated sludge method and there is no treatment of the secondary sludge. The municipal authorities indicated that the WWTW was not operating optimally and that there was room for improvement which could complement a biogas project.

The works has two old digesters each with a capacity of approximately 550m³ which have not been in operation for many years. It is questionable whether these digesters will still be structurally sound to warrant refurbishing them and it might make more economic sense to build new digester tanks.

Based on the process employed by the Maletswai works and on some necessary assumptions, in terms of technical feasibility, it is possible to install a relatively small CHP plant of only 23kWe, potentially generating 180 000 kWh per annum.



Digesters at Maletswai WWTW



A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

The Maletswai municipality is currently serviced by two landfill sites. For the landfill in Aliwal North, there is cur-

rently no weighbridge but it is estimated by the municipal authorities that approximately 67.5 tons per day is disposed into this landfill – excluding weekends when private individuals dispose garden refuse. A conservative estimate of some 25 000 tons per annum of waste was ascertained to be disposed at the Aliwal North landfill.

A Material Recovery Facility (MRF) was being commissioned



Structure of future MRF in Maletswai LM

in Aliwal North at the time of this report with a view to recovery of recyclable materials. However, it may have the added benefit of separating out organic wastes, which could potentially be used for anaerobic digestion. This would need to be further investigated once operational.

The primary agricultural activity in the municipality revolved around subsistence farming and the development of emerging farmers. These activities are characterised by small-scale operations of free-roaming livestock (generally cattle and sheep), making the collection of waste unfeasible. The manager of a local abattoir said that the abattoir wash-

down effluent currently runs into the sewer system and to the local WWTW.

The primary large-scale agricultural operation in the vicinity of Aliwal North is Endewell Farm No. 2 Piggery, with around 4 500 pigs. Although the pig slurry is currently used to produce compost, the farm has had trouble marketing this and would therefore be receptive to sourcing an alternative revenue stream for the waste. Electricity is the primary energy requirement of the piggery. The potential electrical output of a stand-alone biogas plant at the piggery could reach up to 170 kWe.

C - Financial Modelling



A biogas plant at Aliwal North WWTW does not show any viability due to limited capacity and low inflow volumes, with insufficient volumes of sludge for conversion into biogas. The operating cost of such a plant will be higher than the potential savings so there is no financial incentive to invest the necessary capital to construct such a plant.

An AD plant at the landfill site utilising the organic fraction

separated by the future MRF could show marginal viability, especially if the added benefits such as the reduction of waste volume, potential job creation and a possible revenue stream from selling the digestate from the AD plant as organic compost to the agricultural sector is taken into consideration. This will, however, require further investigation once the MRF has been operational for a few years.

3.3. Maluti A Phofung Local Municipality - Free State



A - 1) Waste Water Treatment Works (WWTW)

Waste water treatment and associated infrastructure maintenance for the municipality is currently operated by private consultants and contractors. There are seven WWTWs across the municipality, processing from 0.75 ML/day to 16 ML/day with the two largest being a 14 ML/day facility at Harrismith and 16 ML/day in Phuthaditjhaba. The infrastructure is generally in good condition, well

served, and operated with the municipality scoring an average of 85% in the country's 'green drop' assessment. Several treatment technologies are employed across the municipality's WWTWs including the activated sludge process as well as the use of bio-filters. The theoretical electricity yield from the Phuthaditjhaba WWTW is an estimated 90 kWe.



A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

There are currently 2 landfills in operation, one in Phuthaditjhaba and one in Harrismith with an average annual intake of 14 725 and 27 420 tons respectively. There are also plans in place for the construction of one new regional landfill site incorporating all municipalities in the

district. These landfills and waste collection are managed and operated by private waste companies contracted by the municipality. There are some informal recycling initiatives at the landfills, but no specific organic separation taking place.

The Swiss Valley piggery was identified as a potential stand-alone project with some 3 500 pigs and an abattoir on the property. There is potential for electrical generation of an estimated 160 kWe.



C - Financial Modelling

The theoretical electricity yield provides little room for financial viability of the project at the WWTW. However, a stand-alone project at the piggery could prove financially viable, even though this option has not been studied in detail as it was not the focus of the study.

Several public-private contracts are currently in existence in the municipality, including in the solid waste and

wastewater departments. This results in the provision of efficient, well-operated and maintained services. This efficient level of service provision could complement the implementation of a new project positively; however a project champion would need to be identified by the municipality to lead and motivate for the implementation of such a project and ensure liaison between the different departments.

3.4. Umjindi Local Municipality – Mpumalanga



A - 1) Waste Water Treatment Works (WWTW)

The Umjindi WWTW is located just north of the town of Barberton and has a design capacity of 8.4ML/d and a measured peak inflow of 4.3ML/d. The works is divided into two modules of approximate 2.8ML/d and 5.5ML/d capacity respectively, with only the larger unit in operation. Information provided by the works indicates a raw Chemical Oxygen Demand (COD) varying from 300mg/L to 1000mg/L – an average of 600mg/l was assumed for the purpose of this study.

The basic process of the works is as follows:

- Raw inflow with screening, de-gritting channels and flow metering

- Two modules, each consisting of:
 - Digester (un-mixed and un-heated);
 - Modified Ludzack-Ettinger activated sludge plant with anoxic and aerobic compartments;
 - Clarifier for settling and return of activated sludge to anoxic compartment of sludge plant; clear effluent discharges to downstream processes;
 - Combined disinfection utilising a single chlorine contact tank.

There are two functional anaerobic digestion units, of which only one is utilised. The digestion process was adopted as a wastewater treatment process, so there was

Sludge dam at Umjindi WWTW



no capture or flaring of the gas produced. Digested sludge is withdrawn from the anaerobic reactor and discharged into two storage dams from where the sludge is irrigated to adjacent land. There is a belt press for sludge moisture removal which, albeit fully operational, is not currently being used. The works also has a screenings incinerator, but this is not in operation.

Based on the process employed by the Umjindi works and on some necessary assumptions, there would be the technical potential to install a 45kWe CHP plant that could potentially generate 355 000 kWh per annum (see calculation in Annex).

A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

Umjindi collects approximately 43 200 tonnes of solid waste per annum. The Umjindi municipality does not do any waste separation and there is no plan for the installation of a MRF in the near future. It is also worth noting that most



MRF operation will concentrate on separating recyclable material as a priority – separating organic fraction is normally not a priority.

The municipal team mentioned that there were no significant agricultural activities in the area, but that there is a slaughterhouse, the Barberton Abattoir, in the vicinity. The waste from the abattoir currently enters the municipal sewerage after passing through a fat trap and grate.

C - Financial Modelling

The limited quantity of sludge that can be produced by the Umjindi WWTW would only result in electricity generation of approximately 355 000 kWh/year. A biogas plant at Umjindi WWTW thus does not show any viability due to limited capacity and low inflow volumes, resulting in a



low volume of sludge available for conversion into biogas. The operating cost of such a plant will be higher than the potential savings and there will thus be no financial incentive to invest the necessary capital to construct such a plant.

3.5. George Local Municipality – Western Cape



A - 1) Waste Water Treatment Works (WWTW)

The WWTW of Outeniqua and Gwaing have a capacity of 15 ML/d and 12 ML/d respectively with an existing flow rate of 10 – 12 ML/d and 6 – 9 ML/d respectively. These two works are connected via a pipeline where sludge is transferable from the Outeniqua to the Gwaing works. COD levels were noted to be between 600 – 700 mg/L for both works. The combined sludge of both WWTW could theoretically generate up to 0.3 MWe.

There is a digester at the Gwaing for anaerobic digestion of waste sludge from the works. The digester had been mothballed for 6 to 7 years, it is however estimated that the digester, including steering, is still operational.



Inspection of the existing digester at the Gwaing WWTW



A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

The George Landfill site lays juxtaposed to the Gwaing

works – slightly to the North West of the works. The total solid waste generation (of MSW) is around 109,000 tons per year. The composting operation (at Gwaing) comprises the treatment of garden refuse or green wastes only. The Eden District Municipality already has plans in place for Solid Waste Management throughout the Eden Municipal District.



C - Financial Modelling

A potential biogas project of an estimated 300 kW_e generation capacity seems viable at Gwaing WWTW. However, integrated waste planning was being carried out at District Level, hence restricting the positive evaluation of these potential sources to this study. At the meeting with the municipal officials an overview of the future planning by District Waste Management was discussed, which

encompasses these waste-streams. It is recommended that the planning at District Level be first concluded prior to proceeding with any detailed feasibility study for George Local Municipality. The potential for a successful project is however very high and further detailed studies should be conducted to confirm this potential, in cooperation with the Eden District Municipality.

3.6. Tlokwe Local Municipality – North West

A - 1) Waste Water Treatment Works (WWTW)

WTlokwe has one main WWTW with a design capacity of 45ML/day, currently operating at 33ML/day.

The works utilises three different processes in parallel to treat the effluent, which are:

- Trickling filter 13 ML/day
- Bardenpho 10 ML/day
- New BNR 22 ML/day

The average influent COD loading is about 700mg/L. It is estimated that the current total sludge production by the works before digestion is just short of 9 tonnes Dry Solid (tDS) per day. When the works reaches its design capacity this will increase to approximately 12 tDS per day. Currently the sludge is gravity thickened before being pumped to

sludge lagoons around the works. These lagoons are at capacity and plans are underway to put a tender out to dredge the lagoons. The works is investigating the purchase of a belt press to ensure a higher solids' recovery which will increase the lagoon dredging intervals significantly. The works will have to then implement a sludge handling and disposal programme after the commissioning of the belt press.

The works has a total of four digesters each with a capacity of 1830m³. One of the digesters has a cracked roof and is no longer used by the works. The remaining digesters are mixed by roof mounted draft tube mixers. Although a boiler was installed to heat the digesters in 2001, it was never commissioned – the digesters are therefore not heated at present. The biogas yield potential could be increased



Existing digester at Tlokwe WWTW

significantly should the digesters be heated, which can be done by installing external heat exchangers.

Overall the digesters are in good condition and it seems that the digester with the broken roof could be repaired cost-effectively. The majority of the mechanical equipment will require servicing, upgrading or replacement to ensure the digesters operate optimally. All of the existing gas collection pipe work on the digesters must be replaced.

Although three of the four digesters are currently utilised there is no data available as to the volumes and quality of biogas produced. The works has a dual fuel incinerator installed at the head of works to burn the screenings, as well as a biogas storage tank. The plant staff confirmed that when the system runs there is sufficient biogas produced to fire the incinerator. There is a flare installed at the head of works which burns the excess gas when the incinerator is not running.

Based on the full design flow for the Tlokwe WWTW, it was estimated that the biogas production could lead to an installed capacity of 370 kW_e. In order to realise the full biogas potential of the works, small process modifications would be required.



Google view of the Tlokwe WWTW



Existing 1000m³ biogas storage tank



Biogas incinerator



A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

The municipality collects on average 7300 tons of waste per month based on figures supplied. The average garden

waste is 922 tons and domestic waste 1650 tons per month. Currently no waste separation is done in Tlokwe, although the municipality has applied for funding to install a MRF. A number of industries in the greater Tlokwe municipal area produce organic waste that could potentially be used as feedstock for digesters. These include waste from abattoirs, food waste, waste from fruit and vegetable packaging plants, food processing plants, etc.



C - Financial Modelling

Based on the study conducted at the Tlokwe Municipality, there is clear indication that a viable biogas plant could be established at the WWTW. This finding is based on utilising only the sludge produced by the actual WWTW to generate electricity. The project will entail the upgrading of the existing digesters, installing heating to the digesters, replacing all existing gas piping and the installation and

commissioning of a complete biogas CHP unit, inclusive of all electrical, control and instrumentation, pipe and civil works. The new biogas plant could provide approximately 40% of the electricity requirements of the WWTW with a payback time of eight years, after first high-level financial estimations.

3.7. Newcastle Local Municipality - KwaZulu-Natal



A - 1) Waste Water Treatment Works (WWTW)

Newcastle Local Municipality has 4 WWTW, the main one being Newcastle WWTW. The design capacity of the Newcastle WWTW is 25ML/day and the works is currently running at an average of around 19ML/day. The works is comprised of the following sections:

- Head of Works,
- Two stage anaerobic pond system,
- Trickling filter plant complete with Primary Settlement Tanks (PSTs) and clarifiers,
- Maturation pond,
- Disinfection plant,
- There are also three anaerobic digesters.

The works is currently undergoing refurbishment, which includes head of works, refurbishment of the PSTs, de-sludging of the two first stage anaerobic ponds and the first second stage anaerobic pond as well as emptying and cleaning of the digesters.

From the head of works, the flow is split 70:30 between the PSTs and the anaerobic ponds respectively. The arrangement of the Newcastle WWTW does not allow for effective primary sludge settlement before the anaerobic ponds. Assuming that the influent characteristics of the works are typical of works that treat predominantly domestic sewage, the total sludge is in the region of 4.5 to 5 tDS per day. However 70% of this sludge, after the refurbishment, would be retained in the anaerobic ponds.

Assuming the balance of the sludge is carried through the PSTs, less than 0.75 tDS per day primary and less than 0.25tDS per day sludge treated through humus tanks are expected to be available for the digesters.

The WWTW has three digesters of 1980m³ each, two of which are currently being refurbished as part of a general plant upgrade contract. The digested sludge is dried on the drying beds at the works and thereafter the dried sludge is stockpiled on site.

The biogas potential from the digesters is very low, due to the WWTW utilising anaerobic ponds as a treatment step. The maximum electrical potential from this works is anticipated to be less than 30kWe.



Google view of the Newcastle WWTW



A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

Newcastle Municipality has implemented waste separation at source with what they refer to as a “Two Bag System”. Unfortunately the separation is based on recyclable materials (plastic, paper and tin) going into one bag and the balance of waste into the other bag, organic wet waste

is therefore not separated by itself. Practical organic wet waste collection will therefore still be dependent on the establishment of a MRF.

Newcastle municipality did provide some detailed statistics on the MSW collected based on the “Two bag system” as well as controlled measurement implemented at the landfill site.

Based on the pie chart provided by the municipality (see diagram), 31% of the 140 tons collected MSW is organic and could be used as feedstock for a biogas plant. Should a MRF be commissioned at a future date, there might therefore be financial viability to establish a viable biogas plant based on the organic fraction of the MSW only. This could be in the form of a standalone project based at the landfill site. A landfill site does not have high electricity consumption and the project would have to make provision for excess electricity to be fed back into the municipal grid.



Digester being de-sludged

C - Financial Modelling



The main Newcastle WWTW has a flow rate of 19ML which indicates project viability. The works is also currently busy with a refurbishment contract for the upgrading the digesters and de-sludging of the settling ponds that could potentially reduce the capital investment required for a biogas plant. The process of settling ponds at the plant, however, retains up to 70% of the sludge that is therefore not available to be fed to the digesters, thereby

drastically reducing the quantity of biogas that can be produced. Due to the treatment process employed by the Newcastle WWTW, there is therefore little potential for the establishment of a viable biogas plant based on utilising sludge only. Biogas could, however, become an option if and when the anaerobic ponds are deactivated and the project would have to make provision for excess electricity to be fed back into the municipal grid.

3.8. Greater Tzaneen Local Municipality - Limpopo



A - 1) Waste Water Treatment Works (WWTW)

Tzaneen has one main WWTW serving the town of Tzaneen with a design capacity of 8ML and currently running at approximately 6ML/day. The effluent flows from the head of works to the PST. Approximately 40% of the sludge is drawn off from the PST and pumped to the digesters. The PST effluent is pumped to the trickling filter

and subsequently to the humus tank. The supernatant is pumped to the activated sludge reactor and the humus sludge is pumped to the digesters. Waste Activated Sludge (WAS) and sludge collected by the clarifiers are pumped to the digesters and the effluent is sent to disinfection. After disinfection the final effluent is discharged to the river.



Main reactor at Tzaneen WWTW

There are two digesters, one of 1000m³ and a second of 3000m³. None of the digesters are either mixed or heated at present. Some mixing is facilitated by circular pumping. The digested sludge is dried on the drying beds and then collected by farmers for land application.

Based on the process employed and on some necessary assumptions, there is the technical potential to install a 50kW_e CHP plant at Tzaneen WWTW.



The larger 3000m³ digester at Tzaneen WWTW



A - 2) Additional Organic Waste

No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

No written feedback from the municipality on was received on MSW. The information reflected in this section was verbally obtained from the foreman of the landfill contractor on site at the time of the site visit. The landfill is licensed and is operated by an appointed contractor. The site receives approximately 22 tons of mixed solid waste per day. The landfill covers an area of 11 hectares and, according to the contractor, has a projected lifespan of

another 13 years. The landfill does have a separate area for garden waste which is operated by a separate contractor. Green waste is placed in large wind rows and turned on a regular basis to make compost. No figures were available on what percentage of the collected 22 tons is from garden waste. There is no official separation done by the municipality, either at source or at the landfill, although some informal separation is done at the landfill.

The Tzaneen area has a number of fruit packaging and processing plants, especially based on avocados and mangoes, of which the largest is Westfalia, the primarily generate soil sludge from the fruit waste from its avocado oil production process.



C - Financial Modelling

The low daily flow at the WWTW might not allow for enough electricity generation to prove financial viability as a stand-alone project. Currently the WWTW disposes of its screenings at the local landfill. There may thus be both a financial and environmental case to be made to capture the

biogas solely to run a biogas powered incinerator to destroy the screenings at the WWTW. The avocado oil available from commercial activities is a very attractive option in theory and could potentially lead to a stand-alone biogas project.

3.9. //Khara Hais Local Municipality - Northern Cape



A - 1) Waste Water Treatment Works (WWTW)

The Kameelmond WWTW is located to the south-west and down river of the town and is the only waste water treatment plant serving the town of Upington. The installed capacity of Kameelmond WWTW is 16 ML/day and is currently treating 14 ML/day. The works will require refurbishment and upgrading in the near future.

Google view of the Kameelmond WWTW



Bio-filters and Primary Settling Tanks at Kameelmond

The effluent from the head of works is pumped up to a splitter box which feeds the four PSTs. The sludge from the PSTs is gravity thickened before being pumped to the digesters while the supernatant is pumped to the trickling filters. The effluent from the trickling filters is then treated in the activated sludge plant. The waste activated sludge is pumped to the drying beds with the digester effluent. The sludge, once dried, is collected by farmers for land application. After the reactor, the effluent is pumped to the clarifiers and the supernatant is pumped to the disinfection plant before discharge to the Orange River.

The works has an incinerator used to incinerate the

screenings – this could potentially be converted to run on biogas. Any biogas from a potential biogas plant would, however, would give a better return by converting it into electricity rather than replacing oil for the incinerator.

At the current flows the works produces about 3.5 tDS sludge per day, which could theoretically lead to the commissioning of a CHP of 85 kWe (see calculation in Annex). The WWTW has two 1850m³ digesters that are not heated and have no mechanical mixers installed. The two digesters are large enough for a solids retention time in excess of 30 days, which is sufficient to stabilise the sludge. The sludge is then solar-dried. The drying beds are



Existing incinerator

large and more than adequately sized for the total sludge volumes produced by the works. Staff at the works claim there are no fly or odour problems, which bears testament to the efficacy of the drying beds and a well stabilised

sludge. The farmers collect the dried sludge from the works at their own cost for use on their crops. The works never has to stock pile sludge as the demand exceeds supply.

A - 2) Additional Organic Waste



No other readily available feedstock for co-digestion was identified.

Additional information on Municipal Solid Waste and other agro-waste potential identified:

The Khara Hais municipality manages its own landfill site, but only collects around 10t of waste per week. The municipality indicated that the organic fraction of MSW

is only in the region of 10% and no separation at source is currently in place. These numbers are too low to be of significance when considering a biogas plant.

Local agriculturalists indicated that they are considering installing their own biogas projects in the future and therefore there is no security for obtaining additional feedstocks from agricultural waste in the future.

C - Financial Modelling



The current flow at the Kameelmond WWTW is high enough to indicate a technical potential for a biogas plant. However, due to the current state of the works, the merit in a standalone biogas project is questionable. The main reason is that even if the digesters are upgraded and CHP installed, the works will not be able to supply the biogas plant with controlled quality sludge without the WWTW

first having undergone a full refurbishment. There might, however, be merit in including the upgrading of the digesters and CHP plant as part of a future refurbishment project and conduct a more in-depth study on identifying and sourcing organic waste streams from MSW as well as from private sector companies.

3.10. Summary table

Municipality	Province	Population (according to census 2011)	Number of households (according to census 2011)	Green drop score 2011	Capacity of considered WWTW (ML/day)	Average inflow of water at the time of the study (ML/day)	Digestors	Theoretical installed capacity from sludge (kW) at identified WWTW	Other potential for a biogas project	Comment on potential
City of Tshwane	Gauteng	2,921,448	911,536	64%		220	yes	4 000		Potential exists in several WWTW
Maletswai	Eastern Cape	43,800	12,105		5.5	4.9	2 old (1100m ³)	23	Piggery or MRF	Potential at WWTW limited due to low inflow
Maluti A Phofung	Free State	335,784	100,228	67%	16		?	90	Piggery	Potential at WWTW limited, but good at piggery
Umjindi	Mpumalanga	69,577	20,255	56%	8.4	4.3	2	45		Potential at WWTW limited due to low inflow
George	Western Cape	193,672	53,551	91%	15+12	11+8	yes	300	Combination of the 2 WWTW	Good potential
Tlokwe	North West	162,762	53,537	97%	45	33	4 (7320m ³)	370		Good potential
Newcastle	KwaZulu Natal	363,236	84,272	72%	25	19	3 (5940m ³)	30		Limited potential due to WWTW process
Greater Tzaneen	Limpopo	390,095	108,926		8	6	2 (4000m ³)	50	Avocado industry	Potential at WWTW limited due to low inflow
\\Khara Hais	Northern Cape	93,494	23,245	36%	16	14	2 (3700m ³)	85		Fair potential but WWTW needs refurbishment

4. Conclusion and way forward

The studies identified a number of challenges but also presented some guidelines for further investigation and possible investment. The first challenge was establishing contact with the relevant personnel at the various municipal departments and subsequently obtaining the necessary information. It was also established that an in-depth understanding of the actual operational processes at each waste water treatment plant is required in order to do a realistic analysis of the practical quantity of sludge available to serve as feedstock for the digesters at each waste water treatment plant. The quantity of sludge available will in turn determine the amount of electricity that could be generated and thus ultimately determine project viability. Unfortunately this level of information was either not available or not recorded at the municipalities analysed and would require a more in-depth analysis to ascertain such volumes.

It is worth noting that even though all the waste water treatment plants forming part of these studies have digesters, these were operated to optimise sludge management and not to optimise biogas production. Thus refurbishment of most of the digesters would be needed to effectively harvest the biogas.

An important result of the studies is that there seems to be a definite viability to implement projects at larger WWTW, specifically where the inflow is in excess of 15ML/day. In general these biogas projects will require a long term investment with viable returns only possible over a 7-10 year period. A WWTW with a flow of less than 15ML/day would most likely not be able to produce sludge in sufficient quantities to prove financial viability based upon the amount of electricity it could produce. Additional modelling will need to be conducted to confirm these numbers and estimations.

Despite these challenges to establishing viable biogas projects at waste water treatment plants, the studies have indicated that there is definite viability to implement such projects at larger municipalities. Most of the municipalities reviewed have shown great interest in biogas projects and saw these projects as options to reduce their energy costs, gain some degree of independence from the national grid and 'green' their municipalities by making them more environmentally friendly in their waste disposal as well as from using a clean energy.

A detailed feasibility study funded by SALGA is currently on-going in Tlokwe Local Municipality, analysing in detail the technical and financial aspects to ascertain the feasibility of the project and to provide further guidance to the municipality.

Based on the conclusions and results of the scoping studies presented in this summary report, a guiding tool is currently under development by GIZ. It aims to assist municipalities in assessing, at high level, the technical and financial viability of establishing a biogas project based on sludge from the WWTW. In order for such a tool to be able to provide the necessary information, it will have to receive the required detailed input from the municipality – both from WWTWs and financial perspectives, without which the tool will be of little use. The tool will be MS Excel based and will serve to guide the municipalities before they appoint a service provider to undertake a detailed feasibility study.

Annex 1

Table 1 – Properties and yields for common feedstocks

Feedstock	SS (%)	VSS in %SS	N _{total} in %SS	C/N	Carbon content in %SS	Specific methane production in LN/kg _{SSV_{aff}}
Cereal grains	87	87				370
Potatoes	22	94				380
Apple distillation residue	2 - 3.7	94 - 95		6		330
Potato distillation residue	12 - 15	90	9	6	48	370
Cereal grains distillation residue	4 - 6	95				380
Molasses distillation residue	10.5	71.2				350 - 400
Whey	4.3 - 6.5	80 - 92	1,1	27		350 - 400
Whole milk	13	95				450 - 500
Ricotta	22	95				400 - 450
Bread waste	65	97				400
Market waste	5 - 20	76 - 90	4	15		300 - 400
Oilseeds waste	92	97	1.4	41	57.5	450 - 550
Canola meal	88	93	5.6	8		450 - 500
Glycerol	100	99			39	350
Flotation sludge (Slaughterhouse waste)	5 - 24	83 - 98	6			600 - 800
Grease trap residue	2 - 70	69 - 99	0.1 - 3.6			600 - 700
Carcass meal			8 - 12	2.5 - 5		500 - 600
Blood meal	90	80	12	4	48	450 - 520
Food waste	9 - 37	74 - 98	0.6 - 5.0	15 - 21	0.04 - 0.18	400 - 500

Table 2 – Summary of waste streams suitable for co-digestion in WWTP

Substrate	limited	suitable	good
Food processing			
Market waste, restaurant waste and expired food			X
Grain dust, seasoning residues, residues from maize and rice production		X	
Dough residues			X
Tobacco dust, slack and slurry		X	
Spent malt, hops, malt culms		X	
Fruit, cereal and potato slops		X	
Trod and slurry from the breweries		X	
Slurry from vineyards and distilleries		X	
Coffee, tea and cacao fabrication residues		X	
Yeast and yeast like residues			X
Waxes	X		
Fat residues		X	
Whey		X	
Water processing and sewage treatment			
Sedimentation sludge	X		
Raw sludge, fecal sludge		X	
Animal by-products			
Pig and cattle manure, poultry dung, manure		X	
Springs, bristles and horn residues, bone residues and skin remains	X		
Poultry and fish residues		X	
Offal and blood		X	
Stomach, intestine contents and other animal body parts		X	
Waste and production residues			
Bio waste from separated waste collection		X	
Garden waste	X		
Slurry from paper, pulp and cellulose fiber, wastepaper	X		
Starch-sludge		X	
Grass clipping, beet leaves, macro-algae		X	

Annex 2

Examples of biogas potential calculations:

- Umjindi WWTW
- //Khara Hais WWTW

Biogas potential calculations for Umjindi WWTW:

COD in raw (assumed)	600	mg/l
COD % settled	35%	
TSS in raw (assumed)	285	mg/l
TSS % settled	60%	
Primary sludge mass	957.6	kg/day
Primary sludge VSS/TSS	0.81	
Primary sludge VSS consumed	411.0977	kg/day
Reactor sludge age	15	day
WAS mass	533.4234	kg/day
WAS VSS/TSS	0.75	
WAS VSS consumed	127.9526	kg/day
Combined sludge mass	1491.023	kg/day
Solids retention	30	day
Digester operating temp	20	°C
Digestate solids mass	951.9731	kg/day
Biogas production	485.1453	m ³ /day
Electrical power potential	44.47165	kWe

Biogas potential calculations for //Khara Hais WWTW:**Gas Calculations**

Total Flow	14	MI/day
Expected Sludge Content	0.25	
Total Sludge per Day	3.5	t/day
Primary Sludge to AD	Yes	50%
Humus Sludge to PST	Yes	30%
WAS to AD	No	20%

	DS kg/day	VSS %	ISS %	Destruction Rate	Coverion Efficiency	Biogas (m ³ /day)
Primary Sludge	1.750	80%	20%	50%	95%	665
Humus Sludge	1.050	75%	25%	45%	95%	337
Waste Activated Sludge	0	70%	30%	40%	90%	0
						1.002

Methane Content	62%
Electrical Efficiency	35%
Power Factor	0.95

Kilowatt (electrical)	86
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Hours per year	8760
Availability	95%

Kilowatt Hours per year	716.009
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Digester Claculations

Digester loading rate	2	
% VSS in sludge	78%	
Total VSS per day	2.188	kg
AD Volume required for VSS	1.094	m ³

Range: 1.6 to 3.2kg / m³ / day
 Typical: Primary 80%, WAS 60%

% DS to AD	2.5%	
Total volume sludge per day	112	m ³
Retention time	33	days
AD Volume required	3.696	m ³

Range: 0.5% to 5%
 Assume 1t sludge = 1m³
 Range: 15 to 25 days

Digester Capacity	3.700	m ³
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Abbreviations

AD	Anaerobic Digestion
CH ₄	Methane
CHP	Combined Heat and Power
CO ₂	Carbon Dioxide
COD	Chemical Oxygen Demand
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GW	Gigawatt
kWe	kilowatt electrical
kWh	kilowatt-hour
LM	Local Municipality
m ³	Cubic meter
mg/L	milligram per litre
ML	Mega litre
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
MWe	Megawatt electrical
NERSA	National Energy Regulator of South Africa
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PST	Primary Settling Tank
ROI	Return on Investment
SAGEN	South Africa German Energy Programme
SALGA	South African Local Government Association
SS	Suspended Solids
TSS	Total Suspended Solids
tDS	tonnes of Dry Solids
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTW	Waste Water Treatment Works

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