GreenCape

Industry Brief
2021

Waste-to-Energy: Is it viable for your business?

Key Insights

There is an increasing need for businesses to **reduce their energy demand** and **to secure energy supply; improve water efficiency;** and **reduce and beneficiate waste streams.** This is the result of crises in energy and water supply and due to reduction in landfill airspace and implementation of landfill bans.

Waste-to-energy solutions are one way that businesses could potentially address these challenges[1]. Waste-to-energy can, in some cases, **reduce waste management and utility requirement costs**, as:

- The gate fees of many of these solutions are often cheaper than landfill gate fees.[2]
- Logistic costs for waste management may be reduced.
- Through beneficiation of on-site waste streams with waste-to-energy solutions, businesses can reduce the amount of waste to landfills, reduce their energy demand from the utility provider's grid and improve their energy security.[3]

There are technology providers that provide circular economy based services that include a combination of on-site waste management, small scale embedded generation for on-site usage, replacement of fossil based fuels with biofuels, wastewater treatment and water reticulation for reuse.

However, the combination services and the business case for the specific solution offered is dependent on unique needs of the business and the site on which the waste is being generated.

The type of waste generated, and the degree of pre-treatment required, will determine the waste-to-energy solution applicable to one's business, as well as the investments required for on-site infrastructure to enable efficient implementation of the selected solution.

Introduction

This industry brief is written for businesses that generate food and other organic wastes and are looking to explore a beneficiation solution to add value to that waste. The brief examines the current context, and opportunities and barriers to successful implementation of waste-to-energy solutions that may benefit one's business.

[1] There are alternatives to waste-to-energy for organics management. These have been outlined in other industry briefs and documents. See, for example, the following: *Industry Brief on Food and Organic Waste Management (2017)* and the *Industry Brief on Food Loss and Waste (2020)*
[2] City of Cape Town charges can be found in GreenCape's 2020 Waste Market Intelligence report at https://www.greencape.co.za/market-intelligence/.
[3] An example is shown in the *2020 WISP Case Study: Vegetable Waste to Value Add Products including Biogas*

Available Solutions

The selection of waste-to-energy solutions available to businesses can be broken down into three main categories, namely anaerobic digestion (biogas), thermal waste-to-energy and biofuels. Each of these categories have a specific[4] type of feedstock (e.g. plant-based materials), but most allow for varied feedstock (i.e. mixed organic waste). Other contextual requirements also need to be met. These feedstock and contextual needs for these waste-to-energy solutions are described in more detail below:

Anaerobic digestion (biogas): Biogas producers rely on anaerobic conditions to process organic waste, agricultural residues, wastewater and resultant sludges into biogas that can be used as a transport fuel as well as a fuel source for burners to generate heat and/or electricity. When generating heat and/ or electricity, biogas can be used as it exits a digestor with minimal treatment. When biogas is used as a transport fuel or fuel to be taken off-site, it is further upgraded (e.g. to remove any sulphurous and other contaminants) and separated into carbon dioxide[5] and a biomethane product[6]. Biogas solutions may require highly specific, high volume, and homogenous feedstocks or skilled feed preparation to enable the use of mixed feedstocks[7].

Thermal waste-to-energy: These are solutions that process **organic and waste residues (e.g. contaminated non-recyclable plastics) with a high calorific value** and low moisture content using thermal processes. These **thermal processes** include **incineration, pyrolysis and gasification** that have the potential to generate heat, electricity, fuel and oil-based by-products. Thermal based waste-to-energy solutions may require highly specific, high volume, and homogenous feedstocks and are most applicable to businesses that have continuous high on-site heating requirements within their processes.

Biofuels: Biofuel manufacturers are able to process energy crops (incl. algae), lignocellulosic (i.e. wood-based) residues, refined vegetable oils and animal fats into an alternative to petroleum based diesel and carbon chain based fuels such as ethanol. The biofuel can be used as a transport fuel, a fuel source for burners to generate heat and/or electricity as well as for specific laboratory-based uses[8]. Biofuel solutions are applicable as both a small scale and large scale solution. However, large scale manufacturing of biofuels is currently governed by a more stringent legislative framework[9].

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[4] For example, minimum tonnage, homogenous, and/or de-packaged waste.
[5] Can be used, for example, for greenhouse crop production, refrigeration and carbonated beverages.
[6] A highly flammable and potent greenhouse gas that, when burnt, converts to heat, water, and carbon dioxide (CO^2).
[7] See GreenCape's *2018 Biogas project development life cycle* publication compiled for the UNIDO waste-to-energy project in South Africa and *Waste MIR* for more information of feedstock requirement and preparation.
[8] These include hydrocarbon based alcohols and oils such as ethanol
[9] Governed by the same regulations as fossil-based liquid fuels

Regulations affecting waste-to-energy solutions

In South Africa, there are a number of policies and regulations that need to be considered when developing and implementing a waste-to-energy solution. The legislative framework governing a selected solution is dependent on the contextual need[10] of the business. For a breakdown of the relevant legislative considerations for waste-to-energy solutions, see Annexure 1 (page 8).

For waste-to-energy solutions, feedstock management is governed by the National Environmental Management: Waste Act (59 of 2008) (NEM:WA) and the collection and storage of waste is regulated through subsidiary legislation (i.e. norms and standards, regulations). These solutions would require (in most cases) the completion of an environmental impact assessment. Plant construction, operations and maintenance is governed by relevant building regulations and the Occupational Health and Safety Act (85 of 1993).

The energy products manufactured by these solutions are governed by the existing energy policies and regulated by the National Energy Regulator of South Africa (NERSA). Thus, should the selected solution include **waste management** and **energy generation**, your company and any company you use to assist you in the implementation of these **solutions, needs to adhere to national and provincial laws, and local government by-laws**.

Broadly, municipal by-laws regulate the service provided to the waste generator and/or may impose further obligations for the management of waste generation (i.e. waste avoidance and minimisation), as well as cleaning, separation, storage, collection, processing, treatment, recycling, re-use and disposal of waste. In addition, the municipal by-laws may include a small scale embedded generation framework and a set feed-in tariff.

The future for waste-to-energy solutions

As the market for waste-to-energy solutions grows, more relevant legislation and standards will be implemented to ensure that these solutions are implemented in a safe and a sustainable manner.

The following policies, frameworks and legislation, are currently in process of being implemented:

- **National Norms and Standards for Treatment of Organic Waste (The initial deadline for public comments of in 30 April 2021 was extended to 31 July 2021)**
  - This would reduce and ease the licensing and permitting required for the implementation of waste-to-energy solutions
- **Implementation of landfill waste bans**
  - The Western Cape will impose 50% and 100% organic waste to landfill bans by 2022 and 2027, respectively. This will require municipalities to set annual targets, and to identify and implement procedures to meet these targets, resulting in an increased demand for waste-to-energy from both the private sector and municipalities.
- **Amendments to Electricity Regulations Act (4 of 2006)**
  - Amendments of Schedule 2 that have been announced by the President increase the threshold for generation license capacity for independent power producers to 100 MW whether grid connected or not. Facilities will still need to be registered with NERSA and comply with the transmission grid regulations, as required by Eskom and/or municipal grid requirements, if grid-connected. This is a significant enabler of on-site waste-to-energy projects.
- **Draft amendments to the Petroleum Products Act (120 of 1977) (The period for public comments was completed from 30 March 2021 to 29 May 2021).**
  - Amendments include regulations regarding the mandatory blending of biofuels with petrol and diesel which would increase the market demand for biofuels.

[10] Contextual need refers to the need that a service or solution addresses. Examples would be reduction in energy demand, improved energy security, reduction in waste disposal costs, and waste beneficiation

Market factors influencing the implementation Waste-to-Energy

In addition to the policy and legislative considerations, it is important understand the market factors that influence the development and implementation of a waste-to-energy solution.

These market factors include uptake drivers, barriers / technology restrictions, advantages and disadvantages of waste-to-energy solutions. Table 1 below provides an overview of these market factors.

Table 1: Market factors overview of Waste-to-Energy solution[11]

Waste-to-energy type	Drivers	Barriers / Technology Restrictions	Advantages	Disadvantages
Anaerobic digestion (AD) (biogas)	- The need to find alternative power for peak periods. - Higher cost of organic waste disposal in some areas and for some waste streams. - Biogas as a fossil based energy alternative has a relatively higher contribution in terms of jobs/MW. - High potential for circular economy model implementation by including energy, waste and water applications.	- Requires intensive monitoring and control over conditions to maintain the digestion process. - Can be sensitive to imbalances in feedstock (e.g. high quantities of food versus garden waste or vice versa).	- AD has potential for treating a variety of organic waste streams. - Emissions of greenhouse gas and harmful gases are prevented. - AD has the potential for energy production.	- Requires on-going management and monitoring. - Health and safety issues can arise at AD plants. - Significant odour issues. - Quality is often insufficient for the digestate to be used as a soil enhancer.
Thermal waste-to-energy: Incineration	- Robust alternative to landfill as it uses a large majority of waste streams as feedstock. - Can offer a decentralised waste management and energy option.	- Not suitable for bulky or large items. - Will destroy all non-metal recyclable materials. - Requires a specialist grate to handle higher temperatures generated by refuse derived fuel (RDF). - Energy recovery efficiencies are lower for electricity than heat.	- Incineration is a robust technology than can be used to treat a variety of waste streams. - Revenue from both gate fees and energy generation can make the technology competitive.	- Incineration is capital intensive. - Large quantities of waste to incineration can alter plans for recycling and reuse of waste. - Flue gases can pollute the environment[12]. - Requires feedstock to be pre-treated to a RDF, or a local producer of RDF.

[11] This table was compiled using insights from the following resources: GreenCape's [2018] Biogas project development life cycle; Department of Environment, Forestry and Fisheries'
[12] Alternative Waste Treatment Guide and GreenCape's [2020] Waste market intelligence report.
Flue gas containing dioxins are a major health issue concern and although modern systems are better designed, if not operated correctly these plans can be highly hazardous as dioxins are very strong carcinogens

Table 1: Market factors overview of Waste-to-Energy solution[11] continued

Waste-to-energy type	Drivers	Barriers / Technology Restrictions	Advantages	Disadvantages
Thermal waste-to-energy: pyrolysis	- Invasive plant species that need to be disposed of can be used as a feedstock[13]. - Can produce alternatives to fossil fuels, that have high demand export and local markets, using problem waste streams such woody waste, contaminated non-recyclable plastics and RDFs.	- Pyrolysis technology is capital intensive. - Pyrolysis is energy intensive which reduces the gross energy output of plant significantly. - Metal and inert material require separation before thermal treatment if they are intended for removal.	- May be used for all types of solid products. - Can be easily adapted to changes in. feedstock composition - Can be integrated into micro turbine, fuel cell or thermophotovoltaic (TPV) systems for power generation.	- High capital costs. - Qualified and experienced personnel needed to operate machinery.
Thermal waste-to-energy: gasification	- Invasive plant species that need to be disposed of can be used as a feedstock. - Can produce alternatives to fossil fuels, that have high demand export and local markets, using problem waste streams such woody waste and RDFs.	- Gasification systems are capital intensive. - All non-metal recyclable materials will be destroyed. - Fuel is bulky and frequent refuelling is often required for continuous running of the system.	- Captures carbon dioxide which is harmful to the environment. - Provides energy security.	- Significant capital costs for these facilities. - Requires highly skilled operators. - Requires specific feedstock to gain the full potential of gasification technology.
Biofuels	- Can use feedstocks, such as invasive alien vegetation, energy crops and algae. - Can use energy crops that grown on land that is being rehabilitated. - Mandatory blending regulations that increase the demand for increased volumes of biofuel being produced. - Sugar Value Chain Master Plan to 2030[14] formally signed on 16 November 2020 which places a significant focus of the potential of biofuels and its role in diversifying product portfolio of the sugar industry.	(- Local and international outcry on land use management – energy crops vs food security debate. - Liquid based fossil fuels demand is on a decline and therefore the market potential may be overstated. - Large scale manufacturing (> 300 000 L per annum) is governed by the same legislation as liquid based fossil fuels. - Lack of a standard for the quality of biofuel produced.	- Production of biofuel can have a lower carbon footprint than fossil fuels. - Technology can be used with energy crops grown on land that is required to be rehabilitated and restored. - Has three generation options for feedstock. The 1st generation uses energy crops, 2nd generation uses lignocellulosic (woody) residues and 3rd generation uses algae.	- 1st generation biofuel technologies have a lot of resistance due food security concerns. - 2nd and 3rd generation biofuel technologies do not have a track record and therefore carry a high financing risk. - Large capital cost for plants that operate at international standards.

[13] Removal invasive alien vegetation can assist in improve water security, waste management and reduction in carbon emissions
[14] https://sasa.org.za/wp-content/uploads/2020/11/SA-Sugar-Master-Plan-1.pdf

Determining the viability of waste-to-energy solutions for your business

Understanding the project development process for waste-to-energy solutions is a key step to improving the chances of implementing, operating and maintaining a project for the entirety of its life span.

Figure 1 provides an overview of the steps and risk considerations for the development process for waste-to-energy solutions.

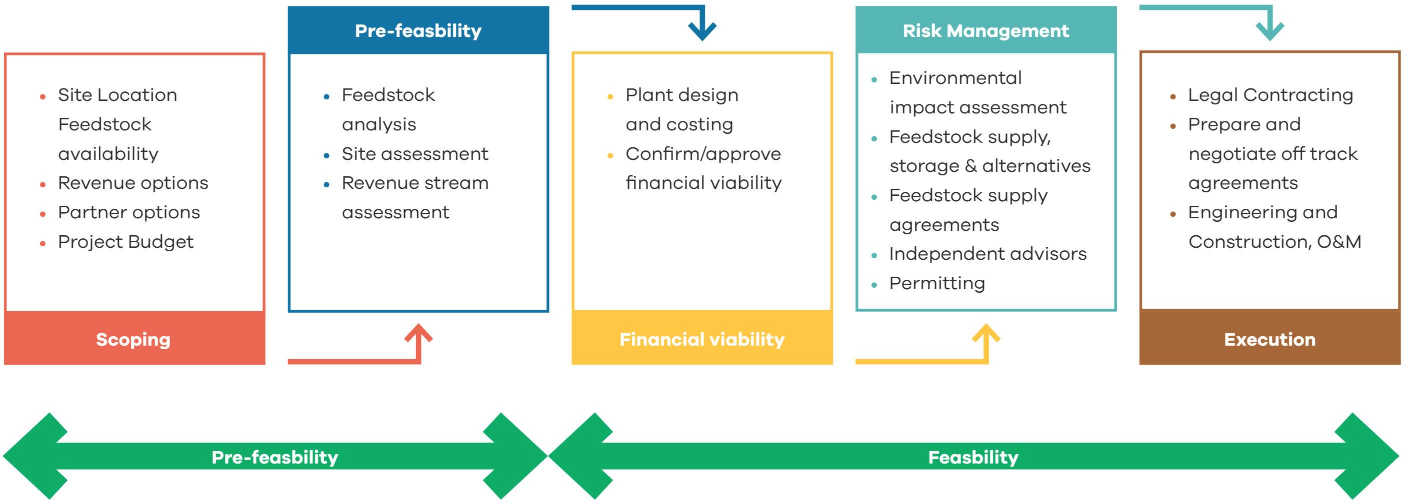

Figure 1: General considerations for development waste-to-energy project solutions[15]

As a minimum requirement, a thorough understanding of the value and limitations of a waste-to-energy solution within your business context is needed before proceeding to physically implementing the solution. It is suggested that you partner with a service provider with the necessary skills set and do not cut any corners when developing these solutions There are a handful of best practices with regard to project feasibility and viability assessment that will increase your ability to assess the viability to implement a waste-to-energy solution within your business.

These include, but are not limited to:

- **Pre-feasibility:** The pre-feasibility is divided into two stages, namely scoping and pre-feasibility assessment. The scoping is a theoretical assessment to gain an understanding of the minimum feedstock requirements (quantity and availability) of a potential solution that you have identified. The feedstock is the basis on which all waste-to-energy solutions are built. Additional considerations when scoping the project may include assessing the location of the solution and energy usage options of the products produced. It is equally important to identify what partner options[16] are available and to understand the budget that is available to your business for developing the solution identified.

  It is at the pre-feasibility stage that the viability of the solution being considered is assessed more practically and realistically. The prefeasibility assessment includes testing if the feedstock meets the solution needs; if the site location is conducive to implementing the solution; and if the products of the solution have a value and market demand. Completing this stage effectively will improve the success rate of developing the solution further to financial close and later the practical implementation stages of constructing and commissioning the solution.

- **Feasibility:** More detailed planning and development of the solution is completed within this stage. This is often completed by a relevant turnkey provider that has the expertise to design and select the appropriate technology solution supplier to meet the needs identified in the pre-feasibility stage. It is also within this stage that all licensing, permits and legislative assessments are completed, along with a full risk analysis and development of a risk mitigation strategy.

The effectiveness of the feasibility stage will dictate the readiness for execution of the solution within your business.

[15] For more detail, see GreenCape's 2018 Biogas project development life cycle publication compiled for the UNIDO waste-to-energy project in South
[16] Partner options may include a turnkey provider, site owner, feedstock generator, product off taker, financial investor, etc. The potential of the solution selected will provide an understanding of the expertise gaps you need a partner to address.

Conclusion

South Africa, and the Western Cape in particular, has experienced increasing interest in waste-to-energy solutions as these are viewed as a solution that address the current energy crisis and potentially turn "problematic waste" into a usable commodity.

Waste-to-energy solutions are perceived as expensive compared to other renewable energy and waste management solutions when viewed in isolation as an energy or a waste management solution. However, should a waste-to-energy solution be implemented as a **collective solution for waste management, reduction of grid or fossil-based energy demand and energy security**, in specific contexts, it can be more viable than implementing individual renewable energy and waste management solutions in isolation.

Many businesses, especially those that produce large volumes of agricultural residues and food wastes can reap the benefits of well implemented waste-to-energy solutions. However, as outlined in this brief, it is very important to understand the current needs and limitations of your specific business and to explore alternatives, before implementing any waste-to-energy solution so that the selection waste-to-energy is the correct solution for your business and an appropriate waste-to-energy technology is chosen.

The next step?

For more help on waste-to-energy solutions, or if you have any questions about this brief, please contact GreenCape's bioenergy and waste teams via: waste@greencape.co.za.

GreenCape

GreenCape is a non-profit organisation that drives the widespread adoption of economically viable green economy solutions from the Western Cape. Our vision is for South Africa to be the green economic hub of Africa. We work with businesses, investors, academia and government to help unlock the investment and employment potential of green technologies and services, and to support a transition to a resilient green economy.

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Disclaimer

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Annexure 1: Legislation and policy requirements for waste-to-energy solutions

Table 1: Breakdown of legislative requirements for waste-to-energy solutions[17]

1. **Energy and Environmental Policies**
   - Renewable energy policies
   - Climate change policies
   - Agriculture policies
   - Waste policies
   - Natural gas policies

2. **Socio / Political**
   - Government procurement policies[18]
   - Broad-Based Black Economic Empowerment (BBBEE)
   - Employment Equity

3. **Economic and Financial Policies**
   - Feed-in tariffs
   - Grants / soft loans[19]
   - Exchange control[20]

4. **Research and Development**
   - Coordinated (large-scale) R&D programmes[21]

5. **Other Support Schemes**
   - Long-term government planning documents[22]
   - Partnerships between the public and private sectors[23]

6. **National Environmental Management Act (NEMA) Act 107 of 1998**
   - Overarching environmental legislation which provides for Special Environmental Management Acts (SEMAs)
   - Listed activities with thresholds which determine if authorisation is required
   - Enabling legislation for EMPr[24], Audits, Appeals
   - National Environmental Management Waste Act (NEM:WA) – Waste Management Licence
   - National Environmental Management: Air Quality Act (NEM:AQA) – Atmospheric Emissions Licence (currently being revised)
   - National Environmental Management: Biodiversity Act (NEM:BA) - Permit
   - National Environmental Management: Protected Areas Act (NEM:PAA) – Environmental Authorisation

7. **Other legislation to comply with**
   - National Water Act 36 of 1998
   - National Heritage Resources 25 of 1999
   - Agriculture (SALA[25], CARA[26], Fertiliser Act[27])
   - Planning (SPLUMA[28])
   - Civil Aviation Act 13 of 2009
   - Petroleum Products Act 120 of 1977[29]
   - Biofuels regulatory framework
   - Occupational Health and Safety Act 85 of 1993

8. **National Authority**
   - Waste Management Licence (hazardous waste)
   - Environmental Authorisation for Generation and Transmission of Electricity
   - Water Use Licence (digestate, irrigation)
   - Gas Registration
   - National Heritage Site Management

9. **Provincial Authority**
   - Waste Management Licence (general waste)
   - Environmental Authorisation
   - Provincial Heritage and Biodiversity Site Management
   - Role of Local and Provincial Authorities
   - Air Emissions Licence (District Municipality)
   - Planning permissions

10. **Minimum Requirements for project construction and commissioning [30]**
    - National Gas Act[31]
    - Municipal planning laws
    - Building regulations
    - Engineering and design[32]
    - Site and zoning approvals
    - Fire and safety approvals
    - Environmental and waste approvals
    - Installation and commissioning approvals
    - Operational and trading approvals
    - Recertification and periodic inspections[33]

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17 For more detailed breakdown of the applicable legislation as well as licencing and permits requirements for waste-to-energy solutions you can visit Department of Environment, Forestry and Fisheries' Alternative Waste Treatment Guide website. Additional details specific to anaerobic digestion are also provided in the DiBiCoo Market and Framework Analysis for the South African Biogas Sector.
18 If you would like to access additional feedstock currently managed and owned by municipalities
19 Funding from development financing institutions, direct foreign finance or government funded programmes
20 Foreign exchange rates and import taxes impact development of project if foreign equipment, components and skills are used
21 These include governmental departments and / or municipalities conducting pilot projects to demonstrate technology viability
22 Includes Industry Waste Management Strategies and Integrated Resource Plan
23 Should you decide that one of your partner options is with government, it is important to under how public private partnership can be structured
24 Environmental Management Programs
25 Subdivision of Agricultural Land Act 70 of 1970
26 Conservation of Agricultural Resources Act No. 43 of 1983
27 Fertilizers, Farm Feeds, Seeds and Remedies Act 36 of 1947
28 Spatial Planning and Land Use Management Act 16 of 2013
28 Specifically, for biofuels produced on a large scale (> 300 000 litres per annum)
24 Environmental Management Programs
30 These requirements are all authorised at the local municipality level
31 Framework for a gas installation and management there of
32 By adhering to local standard of practice. Should there be no local standard established, a relevant international standard of practice should be adhered to.
33 With respect to the terms of granted licences and permits and the requirements for extension and / or renewal of these licences and permits